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AFFDL-TR-76-63

AD B018696

LOW-COST AIRCRAFT STRUCTURAL REPAIR AND  
MAINTENANCE STUDY

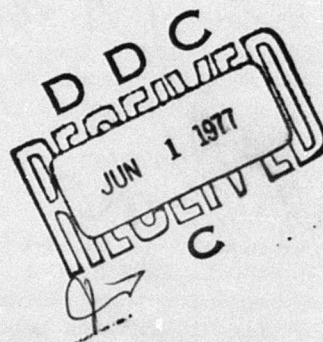
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LOS ANGELES, CALIFORNIA

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MARCH 1977

FINAL REPORT FOR PERIOD AUGUST 1974 - MAY 1976  
TECHNICAL REPORT AFFDL-TR-76-63



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AIR FORCE FLIGHT DYNAMICS LABORATORY  
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES  
AIR FORCE SYSTEMS COMMAND  
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

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This technical report has been reviewed and is approved for publication.

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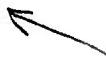
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20. ABSTRACT (Continued)

program was limited to existing military aircraft metallic-type structures since separate programs for adhesively bonded and advanced composite structure design and repair are being developed by the Structures Division (FBS) of the Air Force Flight Dynamics Laboratory. The design handbook has been published as document No. AFFDL-TR-76-72, "Aircraft Structural Design Handbook for Lower Cost Maintenance and Repair."



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## FOREWORD

This technical report was prepared by the Los Angeles Aircraft Division (LAAD) of Rockwell International, Los Angeles, California, for the Advanced Structures Development Branch, Structural Mechanics Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio under Contract F33615-74-C-3101. This research was conducted under Project 1368 "Advanced Structures for Military Aerospace Vehicles", Task 136802 "Advanced Airframes for Military Flight Vehicles". Mr. Clark Bech (AFFDL/FBS) was project Engineer.

The technical effort described in this report was performed between 15 August 1974 and 31 May 1976.

## SUMMARY

This report documents the research and analysis conducted to (1) identify high-cost structural repair and maintenance items in existing U.S. military aircraft, (2) conduct a design study on means to reduce life cycle costs for a number of selected structural problems on fighter, bomber, and cargo tanker class aircraft, and (3) to develop a design handbook to provide guidance and information on methods to reduce aircraft structure cost of ownership. This program was limited to existing military aircraft metallic-type structures since separate programs for adhesively bonded and advanced composite structure design and repair are being developed by the Structures Division (FBS) of the Air Force Flight Dynamics Laboratory. The design handbook has been published as document No. AFFDL-TR-76-72, "Aircraft Structural Design Handbook for Lower Cost Maintenance and Repair."



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## SECTION I

### INTRODUCTION

Substantial costs have been and are being expended by the Air Force each year for the maintenance and repair efforts of the structures on existing inservice aircraft. They constitute a large percentage of the cost of ownership to the military on these systems and have been identified as an area of potential improvement by the Structures Division of the Air Force Flight Dynamics Laboratory.

Many of the cost-associated maintenance and repair problems have been the result of changes in the basic operational missions for which the aircraft was originally designed, significant extension of the service life of the majority of operational aircraft, and the lack of requirements and guidance for aircraft structure maintenance and repair considerations in the original aircraft system specifications. The acquisition costs of aircraft systems in the past have enjoyed the place of prominent consideration for design considerations, with the operational costs being relegated to a secondary role. Recently, the Air Force has become highly concerned with the life cycle costs of all of its existing and future systems. One of the primary objectives of this concern has been the reduction of operational and support costs related to aircraft maintenance and repair.

Past investigations have indicated a significant frequency of structural defects detected in all types of military aircraft. Extensive structural integrity programs have also been conducted on a number of Air Force aircraft and have provided a wealth of information on operational structural load spectrum, defect detection, and repair concepts. The science of fracture mechanics has been established during the past decade and provides a quantitative means of evaluating the choice of materials and new structural design concepts. The experience and lessons learned from past problems and subsequent solutions thereby provide valuable data for the future.

Recognizing these factors, the Air Force Flight Dynamics Laboratory has sponsored a number of programs dedicated to research and development of design information and guidance that will permit substantial life cycle cost savings to be gained by lower maintenance and repair expenditures on the structural portions of their aircraft.

This report documents the results of a study conducted to identify and develop cost-effective design solutions for selected Air Force aircraft



structural maintenance and repair problems and to develop a design handbook. The program was arranged in five phases as follows:

- Phase I - Data Search and Acquisition
- Phase II - Data Analysis and Selection
- Phase III - Selected Items Analysis and Design Study
- Phase IV - Life Cycle Analysis of Selected Design Studies
- Phase V - Preparation of Design Handbook for Lower Cost Maintenance and Repair of Aircraft Structure

The means by which each of the program phases were conducted and the results obtained are described in subsequent sections of this report. Also included is a summary of the findings and recommendations for future Air Force actions and programs.

## SECTION II

### PROGRAM ORGANIZATION

The program was organized and conducted as shown by the task/event flow diagram in Figure 1. It provides an overall view of each of the tasks performed in the program. Phase I consisted of a data research and acquisition effort where information on current military aircraft structure maintenance and repair problems were obtained through visitations to Government and industry activities, use of Air Force and Navy maintenance reporting systems, and literature searches. The information obtained was then organized, and specific elements were selected for analysis. The information was also placed in a data bank for future use in the program. A briefing and an interim report were then prepared by the contractor and reviewed by AFFDL/FBS. Concurrently with this activity, a detailed program plan was prepared for the conduct of the subsequent program phases.

In phase II, analysis of the acquired data was conducted and a number of critical aircraft structure repair and maintenance items were selected for design study. The selections were representative of problems in fighter, bomber, and cargo tanker-type aircraft. The candidate critical items were documented in a report and reviewed with AFFDL for discussion and approval. The results of the selection were then documented in an interim report for phase II.

Phase III effort consisted of a study to develop candidate innovative design improvements or repairs for the selected critical items that would eliminate or significantly reduce future expenditures of maintenance actions. As each candidate improvement was developed, phase IV life cycle cost analyses were conducted to evaluate the benefits that could be realized. The criterion for acceptance was a break-even point in 3 years after implementation and a significant life cycle cost savings after 10 years. The results of phase III and IV efforts were documented in a report and a briefing presented to AFFDL for review and approval. The candidate structural design improvements and potential savings were presented to the specific aircraft system managers at their respective Air Logistic Centers by AFFDL/FBS. Several of the design concepts are currently being considered for additional study, evaluation, and implementation by these activities.

In phase V, a design handbook, entitled "Aircraft Structural Design Handbook for Lower Cost Maintenance and Repair," was developed. It contains information and guidance on methods to achieve lower maintenance costs on existing and future aircraft systems.

Detailed summaries of each of the program phases are contained in Section III of this report.

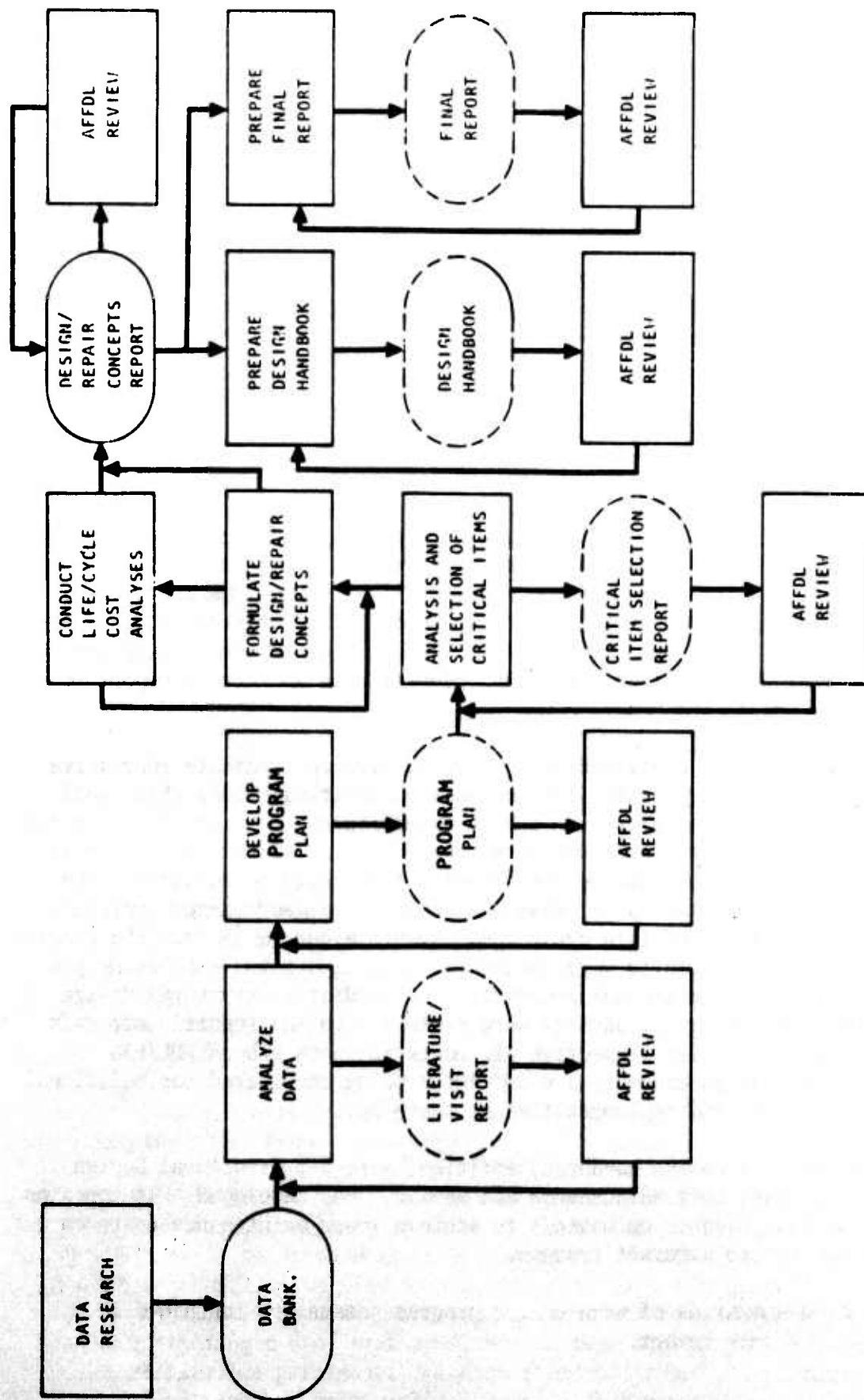


Figure 1. Program task/event flow diagram.

## SECTION III

### PROGRAM SUMMARY

#### PHASE I - DATA RESEARCH AND ACQUISITION

The objectives of the data research and acquisition were to (1) conduct visitations to selected military and industry aircraft repair facilities to identify and document structural maintenance and repair problems on existing operational aircraft, (2) obtain and analyze AFM66-1 maintenance and IROS data, and (3) conduct a literature search for relevant information and data.

In this program, aircraft structure was defined as those elements normally associated with the airframe and the interfaces with other major subsystems where structural loads are accepted. This included the landing gear, flight controls, propulsion system, and crew stations.

Visitations were made to the military and industry activities shown in Table 1. They included Air Force Air Logistic Centers (ALC's), Navy Aircraft Rework Facilities (NARF's), commercial airlines, and aircraft manufacturers. The specific aircraft for which each activity has responsibility is also noted in the table. Specific information was sought in these visits. Figures 2 and 3 show the type of information sought at each repair activity and for specific aircraft problems and formed the basis for the general discussions. Considerable data and information were obtained during these visits on the most critical and chronic repair and maintenance problems being experienced. The results of the visitations were compiled and summarized into a report for use in the subsequent program phases.

Other sources of information on the Air Force aircraft were the structural repair manuals, inspection manuals, corrosion control manuals, and the illustrated parts breakdown manuals. These were identified and acquired during phase I activities for future use in the program.

A literature search was conducted through the Defense Documentation Center (DDC) to identify published documents on aircraft structure defects, repair and inspection techniques, and innovative repair concepts. A bibliography was obtained, and selected documents were acquired and placed in the program data bank. A systematic data filing and retrieval method was used for the program data bank. As each document was received, it was reviewed and the information relevant to the program was identified. This information was entered on a special form, as shown in Figure 4. Subject descriptors assigned to each document identified the type of information which it contained. Figure 5 is the listing of subject categories that were established for the program. This information on the bibliography form was then keypunched on IBM cards. These, in turn, were used as the input data to a computerized data sorting system, which identified each document containing information on specific subjects to ensure that no useful information was overlooked.



TABLE 1. LISTING OF AIRCRAFT REPAIR FACILITIES VISITATIONS

Organization	Location	Aircraft
U.S. Air Force		
Sacramento Air Logistics Center	McClellan AFB, Calif.	A-1, FB-111, C-121, F-84, F-86, F-100, F-104, F-105, F-111, T-28, T-33, T-39, C-12A, E3A
Ogden Air Logistics Center	Hill AFB, Utah	A-26, F-26, F-4, F-89, F-101
Oklahoma Air Logistics Center	Tinker AFB, Okla.	A-7, B-1, B-52, C-97, C/KC-135, VC-137, E-4
San Antonio Air Logistics Center	Kelly AFB, Tex.	C-5, C-6, C-131, F-5, F-51, F-102, F-106, O-2, T-29, T/A-37, T-38, T-41, T-43, OV-10, C-9
Warner-Robins Air Logistics Center	Robins AFB, Ga.	B-57, B-66, C-7A, C-46, C-47, C-54, C-117, C-118, C-119, C-123, C-124, C-130, C-133, C-140, C-141, F-15, O-1, U-1A, U-3, U-4, U-6, U-10, U-17
Davis-Monthan MASDC	Davis-Monthan AFB, Ariz.	Storage and disposition of all types military aircraft
U.S. Navy Air Rework Facilities		
NARF	North Island, Calif.	F-4, F-14
NARF	Norfolk, Va.	A-6, F-8, C-118, P-2, F-14

TABLE 1. LISTING OF AIRCRAFT REPAIR FACILITIES VISITATIONS (CONCL)

Organization	Location	Aircraft
NARF	Cherry Point, N.C.	OV-10, F-4, C-130, C-131, AV-8
Aircraft Manufacturing Co.		
Northrop Corp Aircraft Division	Hawthorne, Calif.	T-38, F-5
McDonnell Douglas	Long Beach, Calif.	A-4, DC-9, DC-10
McDonnell Douglas	St. Louis, Mo.	F-4, F-15
General Dynamics	Fort Worth, Tex.	F-16, F-111, FB-111
Ling Temco Vought	Dallas, Tex.	F-8, A-7
Boeing Aircraft Corp	Wichita, Kans.	B-52, 707, 727, 737, 747
Commercial Airlines		
Continental Airlines	Los Angeles, Calif.	720, 727, DC-9, DC-10
Eastern Airlines	Miami, Fla.	727, DC-9, L1011
United Airlines	San Francisco, Calif.	727, 737, 747, DC-8, DC-10
TWA	Kansas City, Mo.	707, 727, 747, DC-9, L1011
Western Airlines	Los Angeles, Calif.	720, 727, 737, DC-10

## GENERAL MAINTENANCE FACILITY INFORMATION

DATE _____	
ORGANIZATION _____	LOCATION _____

1. AIRCRAFT TYPE/MODELS SERVICED. TOTAL INVENTORY AND OVERHAUL RATE
2. STRUCTURE INSPECTION TECHNIQUES/EQUIPMENT
3. STRUCTURAL MAINTENANCE/REPAIR EQUIPMENT
4. STRUCTURE MAINTENANCE/REPAIR RECORDS/STATISTICS
5. MOST FREQUENT STRUCTURAL MAINTENANCE/REPAIR ITEM
6. MOST COSTLY STRUCTURAL MAINTENANCE/REPAIR ITEM
7. REPAIR TECHNIQUES UTILIZED
  - a. Permanent
  - b. Temporary
8. COST ACCOUNTING DATA
  - a. Labor
  - b. Material
9. ENGINEERING SUPPORT
  - a. In-house
  - b. Contractor
10. STRUCTURE REPAIR MANUALS/INSTRUCTIONS
11. STRUCTURAL STRESS ANALYSIS REPORTS
12. STRUCTURAL INTEGRITY PROGRAMS
13. OPERATING CONDITION OF AIRCRAFT (I.e., FLIGHT HOURS, PROFILES, ENVIRONMENT, ETC)
14. REPORTING SYSTEMS FOR MAINTENANCE/REPAIR WORK
15. PERSONNEL SKILL LEVELS AND LENGTH OF SERVICE
16. RECOMMENDATIONS FOR IMPROVED STRUCTURAL DESIGN
17. RECOMMENDED STRUCTURAL MODIFICATION TO IMPROVE SERVICE LIFE/MAINTENANCE
18. COMMENTS/OBSERVATIONS

Figure 2. General maintenance facility information.

### SPECIFIC STRUCTURAL REPAIR INFORMATION

ORGANIZATION _____		DATE _____
AIRCRAFT TYPE _____		LOCATION _____
MODEL _____	SERIAL/BLOCK NO. _____	
AIRCRAFT OR PART HOURS _____		

1. PART NO. \_\_\_\_\_ PART NAME \_\_\_\_\_
2. PARTS CATALOG NO. \_\_\_\_\_ REPAIR MANUAL NO. \_\_\_\_\_
3. PARTS CATALOG FIGURE/PAGE NO. \_\_\_\_\_ REPAIR MANUAL PAGE NO. \_\_\_\_\_
4. PART LOCATION IN AIRCRAFT \_\_\_\_\_
5. WHEN DISCOVERED \_\_\_\_\_
6. HOW DISCOVERED \_\_\_\_\_
7. TYPE OF FAILURE \_\_\_\_\_
8. REPAIR OR REPLACEMENT \_\_\_\_\_
9. REPAIR INFORMATION SOURCE \_\_\_\_\_
10. TYPE OF REPAIR INFORMATION \_\_\_\_\_
11. TYPE AND FORM OF MATERIAL IN DAMAGED PART \_\_\_\_\_  
\_\_\_\_\_
12. TYPE OF REPAIR MATERIAL \_\_\_\_\_
13. TYPE OF REPAIR FASTENERS \_\_\_\_\_
14. STRESS REPORTS \_\_\_\_\_
15. FABRICATION METHODS \_\_\_\_\_  
\_\_\_\_\_
16. MATERIAL PROCESSING \_\_\_\_\_  
\_\_\_\_\_
17. REPAIR/REPLACEMENT MAN-HOURS \_\_\_\_\_ LABOR RATE \_\_\_\_\_
18. MATERIALS/PARTS/KIT COST \_\_\_\_\_
19. SPECIAL TOOLS REQUIRED \_\_\_\_\_
20. COST OF SPECIAL TOOLS \_\_\_\_\_
21. TOTAL DOWNTIME OF AIRCRAFT FOR REPAIR \_\_\_\_\_
22. COMMENTS ON DESIGN OF REPAIR (COMPLEXITY, MATERIALS, FASTENERS, FABRICATION DIFFICULTIES)

Figure 3. Specific structural repair information.

23. ACCESS OPENINGS. SUFFICIENT \_\_\_\_\_ INSUFFICIENT \_\_\_\_\_  
IF INSUFFICIENT, GIVE SIZE AND LOCATION OF ADDITIONAL ACCESS  
OPENING(S) RECOMMENDED

24. SUGGESTION TO IMPROVE DESIGN OF REPAIR TO LOWER MAN-HOUR AND/OR  
MATERIAL COSTS

25. OTHER COMMENTS

Figure 3. Specific structural repair information (concl).



Job No.  
Page of

# BIBLIOGRAPHY DATA SHEET

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Columns

	CARD NO. <b>A</b>	Card Columns
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3. Sponsor Report No. ....	A.F.F.D.L.-T.R.-7.0-1.4.9	A21-45
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5. Source Report No. ....	NONE	A56-80

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9. Title ....	INVESTIGATION AND ANALYSIS DEV	B20-49
(Title Cont) ....	ELPIMENT OF EARLY LIFE AIRCRAFT	B50-80

	CARD NO. <b>3</b>	Card Columns
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Title (Cont) ....		C31-50
10. Subject Code	0516222825	C51-80

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SED AIRCRAFT STRUCTURAL ELEMENTS TH		D46-80

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AT HAVE SIGNIFICANT SERVICE FAILURE		E11-45
S LARGE POPULATION FAILURE TABULAT		E46-80

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IGN PRESENTED FRACTURE MECHANICS A		F11-45
NALYSIS METHOD SHOWN		F46-80

USEFULNESS COMMENTS

FORM 1000-J NEW 2-73

Figure 4. Bibliography data sheet.

#### AIRCRAFT TYPE

- 01 FIGHTER
- 02 BOMBER
- 03 CARGO/TANKER
- 04 COMMERCIAL
- 05 ALL TYPES

#### OPERATIONAL FACTORS

- 41 ENVIRONMENT
- 42 LOGISTICS
- 43 MAINTENANCE FACILITIES

#### STRUCTURAL ELEMENTS

- 11 AIRFRAME
- 12 CREW ACCOMMODATIONS
- 13 PROPULSION INSTALLATION
- 14 FLIGHT CONTROLS
- 15 ENGINE MOUNTING
- 16 ALL STRUCTURAL ELEMENTS

#### DESIGN FACTORS

- 51 MATERIAL SELECTION
- 52 PROTECTIVE FINISHES
- 53 FASTENER SELECTION
- 54 FRACTURE MECHANICS
- 55 COMPOSITES/PLASTICS
- 56 CORROSION CONTROL
- 57 REPAIR TECHNIQUES

#### DAMAGE/MAINTENANCE FACTORS

- 21 CORROSION DAMAGE
- 22 CRACKING
- 23 FASTENERS
- 24 COSTS
- 25 MATERIAL PROPERTIES
- 26 ACOUSTIC DAMAGE
- 27 MAINTENANCE PROCEDURES
- 28 FAILURE ANALYSIS/DATA

#### AIRCRAFT MANUALS

- 61 MAINTENANCE
- 62 REPAIR
- 63 CORROSION CONTROL
- 64 PARTS CATALOG
- 65 NDI

#### INSPECTION TECHNIQUES

- 31 VISUAL
- 32 PENETRANT
- 33 MAGNETIC
- 34 EDDY CURRENT
- 35 ULTRASONIC
- 36 RADIOGRAPHIC
- 37 HOLOGRAPHY

#### TRADE-OFF/LIFE CYCLE COST FACTORS

- 71 IROS DATA
- 72 OPERATIONAL COST
- 73 LCC METHODS
- 74 COST PLANNING FACTORS

Figure 5. Subject categories.

The maintenance actions on Air Force aircraft at the organizational (field) level are recorded in the AFM66-1 system. The information is submitted to AFLC and stored on magnetic tape for use in data analysis. In this program, a number of aircraft models were selected for analysis of structural maintenance and repair actions. The criteria for selection of the candidate aircraft were (1) there would be a minimum of two aircraft model types in each bomber, fighter, and cargo/tanker category, (2) the aircraft selected would have experienced significant levels of flying hours in the past, and (3) there are a reasonable number of aircraft in service and would be expected to remain in operational use for another 10 years. The aircraft selected under these ground rules are:

- Fighter/trainers - A-7D, F-4D, F-111A, and T-38A
- Bombers - B-52H, FB-111A
- Cargo/tankers - C-130E, C-141, C-5A, and KC-135

A 12-month period of AFM66-1 maintenance records was selected for each aircraft. The primary criterion was to select a time period where the greatest number of maintenance actions would have occurred. The period between mid-1969 and early 1972 was judged to have the highest flying hours for the majority of the aircraft due to the extensive flying hours related to support of the conflict in Southeast Asia. Three exceptions to this time frame were found to be necessary due to the low number of aircraft in service at that time and to the unavailability of the AFM66-1 data. The magnetic tapes for the following aircraft were obtained from the Air Force Logistic Command (AFLC):

<u>Aircraft</u>	<u>Time Period</u>
A-7D	January through December 1973
T-38	January through December 1973
C-130E	January through December 1973
F-4D	January through December 1971
F-111A	November 1970 through October 1971
B-52H	June 1969 through May 1970
FB-111	November 1970 through October 1971
C-141A	April 1971 through May 1972
C-5A	June 1971 through May 1972
KC-135	January through October 1971

Data on structural maintenance actions were extracted from each magnetic tape. This was accomplished by a computer program that first identified those maintenance actions against the following work unit code (WUC) series:

<u>WUC Series</u>	<u>Subsystem</u>
11000	Airframe
12000	Crew accommodations
13000	Landing gear
14000	Flight controls
23000	Propulsion

Next, structure-related how malfunction codes (HMC's) were selected for on-aircraft defects. Those selected for the program are shown in Table 2.

For the 10 aircraft, over 7-1/2 million AFM66-1 event records were screened. Of these, approximately 866,000 structure-related actions were identified and extracted for analysis. Figure 6 shows the total number of maintenance actions processed on each type of aircraft and the number of structure-related items identified.

The data for each aircraft were then processed with a reliability and maintainability (RAM) computer system that listed and ranked the major WUC contributors of maintenance man-hours (MMH) per flight hour (FH). They were listed for scheduled MMH/FH, unscheduled MMH/FH, and total MMH/FH. An example of the data listing is shown in Figure 7 for the FB-111 aircraft for a 12-month period where 11,362 flights were made in 16,704 operating hours. For example, the No. 1 contributor to scheduled maintenance is the WUC 11ACD, center section skin, with 5.16 percent of all on-aircraft scheduled maintenance. The No. 1 contributor to unscheduled maintenance is WUC 13GAH, main gear tire. (This item was purged from the file during the next phase as the file was reduced to pure structure components.) The main gear tire was also the total major contributor.

A structural maintenance analysis (SMA) computer program was developed to analyze the high contributors to maintenance man-hours. It was programmed to list the WUC of a structural element and identify each HMC recorded against the WUC. It also lists the when discovered code (WDC), the action taken code (ATC), the number of occurrences, and the man-hour time expended. Figure 8 shows an example of the SMA data format for the FB-111A aircraft. A center-section frame (11ACA) was found by the ground crew (WDC "F") to be broken (HMC 070) between flights. Minor repairs (ATC "G") were made on 6 of the items during the reporting period, with an expenditure of 71.0 maintenance man-hours. This would result in an average repair time of 11.8 hours for that specific unit.

TABLE 2. SELECTED HOW MALFUNCTION CODES

Code	Nomenclature
020	Worn, chafed, or frayed
070	Broken
105	Loose or damaged bolts, screws, etc.
106	Missing bolts, screws, etc.
111	Burst or broken
116	Cut
117	Deteriorated
135	Binding, stuck, or jammed
170	Corroded
190	Cracked
425	Nicked
520	Pitted
540	Punctured
585	Sheared
605	Crazed
660	Stripped
731	Battle damage
780	Bent, buckled, collapsed, dented
846	Delaminated
878	Weather damage
910	Chipped
917	Impending failure
935	Scored or scratched
947	Torn



<u>Aircraft type</u>	<u>Total maintenance actions</u>	<u>Structure-related actions</u>
FB-111	93,288	5,416
F-111A	217,835	11,834
KC-135	309,377	30,804
B-52H	425,419	45,809
C-5A	496,120	41,167
C-141	1,872,384	371,311
F-4D	2,011,441	112,564
C-130E	687,572	137,571
A-7D	185,749	24,101
T-38	<u>1,210,680</u>	<u>85,342</u>
	7,509,865	865,919

Figure 6. Total AFM66-1 maintenance and structure-related actions by aircraft type.



MUC	HOW MALFUNCTION CODE	WHEN DISCOVERED CODE	ACTION TAKEN CODE	UNITS	TIME
11ACA	070	F	G	6	71.0
		F	A	1	4.0
	135	Q	G	4	17.0
		H	G	1	1.0

- FLIGHT HOURS: 16704
- FLIGHTS: 11362
- PERIOD: NOV 70 - NOV 71

Figure 8. Structural maintenance analysis for major contributors for PB-111A.

In the same manner, structural maintenance analysis were conducted on the data for each selected aircraft.

#### PHASE II - DATA ANALYSIS AND CRITICAL ITEM SELECTION

The objective of phase II was to conduct a detailed analysis of the data acquired in phase I in order to identify the most costly and frequent structural problems experienced on Air Force aircraft. The results of this analysis were then used to select a minimum of 6 critical items for design study directed to the development of innovative design changes or repairs. The selections were made from the analysis of the AFM66-1 maintenance data and the information obtained from the Air Logistics Centers. The structural maintenance analysis (SMA) identified the top contributors for maintenance of aircraft structures for each of the 10 selected aircraft systems. The top contributors for each aircraft were listed (Figure 9) and analyzed to determine the specific cause for the problem. This was accomplished through use of the illustrated parts breakdown, repair manuals, and direct contact with maintenance personnel at the responsible Air Logistics Center and at selected operational organizations. In many of the cases, it was found that the WUC descriptor was not definitive enough to identify the specific structural element that was the primary problem. Figure 10 shows a listing of some of the top contributors on the FB-111A aircraft where the WDC's were used as an aid in identification of the reason for maintenance actions. Further analysis was then performed to determine the existence of specific problem trends in each aircraft. Figure 11 contains a listing of the descriptor codes used in the analysis. The type of structure involved in the maintenance action was first identified. The structural importance of the item (primary load path, secondary, or other) was then determined. The part form, as indicated by the descriptors in the listing, were next identified. The part material type was also identified to aid in determining any specific trends. A summary sheet was then prepared for each top contributor item, to provide the needed detail information for selection of items for design study. Figure 12 shows an example of one of the summary sheets for an aileron assembly on the F-4D aircraft. It provides the description of the part as to its type of structure, material form and type, its ranking in maintenance man-hours per 1,000 flight hours, ranking in maintenance demand rates (MDR's), and the predominate WDC's and ATC's.

As part of this evaluation, the Air Force increased reliability of operational systems (IROS) data were obtained on magnetic tape. Through the use of a computer search program, the ranking of each identified WUC item in terms of overall maintenance costs were established. This provided an indication of the operational organization costs only, since the costs for repair at the individual Air Logistics Centers are not included in the IROS data.

MAINTENANCE MANHOOR CONTRIBUTOR(S) TO FLIGHT CONTROLS  
F-4D

WUC	NOMENCLATURE	HMC	UNITS	TIME	MMH/ 1000 FH
14210	AILERON ASSY	105	2774	6038.0	34.6916
14310	STABILATOR ASSY	105	2458	4759.7	27.3470
1431B	STEEL TRAIL EDGE	190	296	2842.2	16.3300
14210	AILERON ASSY	106	867	1883.6	10.8223
14510	INBD LEAD EDGE	190	284	1865.4	10.7177
14310	STABILATOR ASSY	190	273	1571.2	9.0274
14310	STABILATOR ASSY	106	556	1213.1	6.9669
1431B	STEEL TRAIL EDGE	105	534	1128.1	6.4815
1431C	ALUM TR EDGE	190	113	980.0	5.6306
14510	INBD LEAD EDGE	105	588	884.4	5.0814
14210	AILERON ASSY	020	330	800.8	4.6010
14210	AILERON ASSY	190	154	693.0	3.9817
14310	STABILATOR ASSY	020	85	599.5	3.4445
14510	INBD LEAD EDGE	106	281	504.9	2.9009
1431C	ALUM TR EDGE	846	64	500.5	2.8756
1431B	STEEL TRAIL EDGE	170	13	490.9	2.8205
14210	STEEL TRAIL EDGE	947	240	490.6	2.8188
1431B	STEEL TRAIL EDGE	106	155	369.2	2.1213
14210	AILERON ASSY	780	109	366.7	2.1069
1431C	STABILATOR ASSY	947	26	324.5	1.8644
1431C	ALUM TR EDGE	105	137	313.8	1.8030
14310	STABILATOR ASSY	170	71	243.8	1.4008
1431B	STEEL TRAIL EDGE	117	26	236.5	1.3588
1431C	ALUM TR EDGE	780	39	234.3	1.3462
14310	STABILATOR ASSY	846	31	214.6	1.2330
14210	AILERON ASSY	117	78	194.5	1.1175
14310	ALUM TR EDGE	106	71	171.4	0.9848
1431C	ALUM TR EDGE	117	14	140.0	0.8044
1431B	STEEL TRAIL EDGE	846	21	137.0	0.7871
1431B	ALUM TR EDGE	947	6	136.0	0.7814

Figure 9. Structural maintenance analysis (sample).



WUC	HOW MALFUNCTION CODE	WHEN DISCOVERED CODE	ACTION TAKEN CODE	UNITS	TIME
11ABD	106	H	G	3	1.3
		H	L	2	0.6
		M	G	3	3.5
	135	F	G	18	26.8
		M	G	2	4.5
11ABE	070	F	G	1	0.5
	105	F	G	16	20.5
		M	L	1	0.3
	135	F	G	6	8.4
		M	G	2	3.5
11ABF	105	F	G	1	2.0
	135	M	G	1	2.0
11ABG	105	F	G	8	11.6
		H	G	2	0.6
		H	L	1	0.1
		M	G	4	2.8
	106	F	G	2	3.0
		M	G	1	1.0
		F	G	6	10.0
	135	M	G	10	18.0
11ABJ	105	F	G	4	5.4
		H	G	2	0.5
		H	L	1	0.1
		M	G	3	2.8
	106	F	G	3	3.0
		M	G	2	3.0

Figure 10. Structural maintenance analysis for major contributors for FB-111A (sample).

# CODING SYSTEM FOR THE COMPREHENSIVE FAILURE DATA FORM

DIVISION	DESCRIPTION	CODE
1. TYPE OF STRUCTURE	AIRFRAME	1
	LANDING GEAR	2
	FLIGHT CONTROLS	3
	OTHER	4
2. STRUCTURAL IMPORTANCE	PRIMARY STRUCTURE	1
	SECONDARY STRUCTURE	2
	OTHER	3
3. PART FORM	FORGING	1
	CASTING	2
	SHEET	3
	PLATE (0.25 & THICKER)	4
	ROD	5
	BOLTS & FASTNERS	6
	EXTRUSIONS	7
	HONEYCOMB	8
	ASSEMBLY	9
	OTHER	10
4. PART MATERIAL	ALUMINUM	1
	STEEL	2
	TITANIUM	3
	FIBERGLASS	4
	MAGNESIUM	5
	COMBINATION	6
	TRANSPARENT	7

Figure 11. Structural information codes.

Figure 12. Evaluation summary sheet (sample).

A total of 241 candidate critical items, discovered during the visitations to the Air Logistics Centers, were also analyzed. Summary sheets were prepared for the most promising of these items to the extent that specific information was available. Copies of all AFM66-1 and ALC items summary sheets are contained in appendix A of this report.

The repair of battle-damaged structure was also investigated through search of AFM66-1 data, HMC how malfunction code 731, and by visitations to Air Force and Navy aircraft repair facilities. It was found that only a small percentage of maintenance actions were attributed to this code. For example, on the F-4D aircraft for the time period of January 1971 to January 1972, of the 112,564 structure maintenance actions, only 266 were reported battle-damaged. This accounts for approximately two-tenths of 1 percent of the total. The highest single repair action was 83.6 man-hours required for a fuselage skin duct (WUC 111BB). A total of 3,094.9 man-hours for battle-damaged repair was reported with an average repair time of 11.6 man-hours per occurrence. On the C-130E aircraft for the time period January 1973 to January 1974, 137-571 structure maintenance actions were identified. Out of these, 23 battle-damaged actions were found. A total of 382.2 man-hours was recorded for repair of these items. An average of 16.6 man-hours for each repair was determined. The highest repair time was 48.4 man-hours for a spar fitting (WUC 1152B). Altogether, there were 14 WUC's identified on this aircraft. The battle-damage reported was less than two-tenths of 1 percent of the total maintenance actions.

From the foregoing data, it might be concluded that the impact of battle-damaged repair upon the total system maintenance costs is miniscule and has no appreciable effect upon life cycle costs. This would be a misleading assumption, since the AFM66-1 data reflect only that battle-damaged repair that was accomplished within the capabilities of the organizational maintenance units. This included only limited damage repair. For any battle damage beyond its capability, the aircraft was set aside for repair by the rapid area maintenance (RAM) teams from the Sacramento Air Logistics Center (ALC). The effort for these repairs was charged to depot maintenance and was not recorded in the AFM66-1 system. Where it was determined that a level of damage repair could not be accomplished by the RAM team in the theater of operation, the aircraft would be disassembled, crated, and sent back to the appropriate ALC. Visitations to each of the ALC's has revealed that no specific accounting was utilized by the ALC's to record the man-hours required for repair of battle-damage alone. Each aircraft was repaired and modified to incorporate necessary Time Compliance Technical Orders (TCTO's) together with the normal inspection and repair as necessary (IRAN) procedures.

Data were obtained from the Sacramento Air Logistics Center on the battle-damaged repair efforts performed by the RAM teams on the aircraft in Southeast Asia. Analysis of this information revealed that the most significant repair factor was the extensive time required to obtain replacement parts or repair materials.

### SELECTION OF CRITICAL ITEMS

In the analysis of the 250 AFM66-1 data items and 241 depot items, it was necessary to develop a set of criteria to be used throughout the analysis, evaluation, and final selection process. The following items were established as requirements to be met by each critical repair item ultimately selected for cost reduction study:

1. Item must be used on a USAF aircraft of significant number in current inventory and placed in service after 1950
2. Item must be on an aircraft with probable active military usage over the next 10 years
3. At least one item must be selected from each aircraft category: fighter/trainer, bomber, and cargo/tanker, with a minimum of 6 items total
4. Item must rank among top maintenance cost contributors
5. Item must have a record of repetitive repair/maintenance action, either in the field or at a depot
6. Item must appear to have a significant cost saving potential

With the foregoing criteria in mind, an evaluation of all items obtained from the data analysis produced 85 depot data items and 69 items from the AFM66-1 data, or a total of 154 which were identified as candidate study items requiring further evaluation. Those depot items which could be identified with WUC were added to the top 25 AFM66-1 items for each of the 10 aircraft in the computer data bank.

A second evaluation produced 65 items which met most of the selection criteria. Further elimination of less profitable items for cost reduction left 26 prime candidates.

The final iterative selection was made using the evaluation summary sheet and judging the life cycle cost saving potentials. Due to the possibility that some items would prove to have no significant life cycle cost reduction potential after detail drawings and cost data were obtained and reviewed, an allowance was made by selecting an initial group of 14 items in order to assure a suitable number for study.

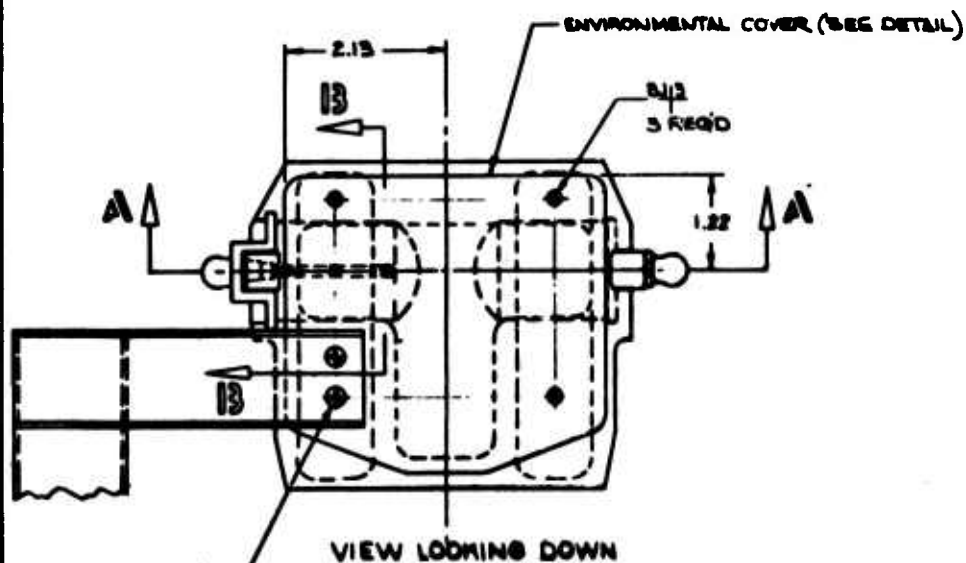


### PHASE III - INNOVATIVE DESIGN STUDY

Upon identification of the 14 selected critical items, drawings on each structural area were ordered from the Air Force Logistics Command (AFLC) Headquarters at Wright-Patterson Air Force Base, Ohio. Costs for the candidate critical items were also obtained through AFLC Headquarters for use in phase IV life cycle cost evaluation. Preliminary design studies were conducted on the candidate items to a degree where 8 could be identified as having the most profitable potential. These are:

- A-7D main landing gear shock and tension strut trunnion and pin assembly
- A/T-37 engine tailpipe clamp
- T-38 removable aft fuselage firewall assembly
- F-4 fuselage fuel tank reinforcement liner skins
- B-52 forward fuselage urinal area
- C-5A wing leading edge slat actuator doors
- C-5A engine cowl door hinge fitting
- C/KC-135 inner to outer wing joint ribs

Each of these items was subjected to a detailed design study to develop either an improved design concept or a cost-effective repair approach. The results of the design study are described in the following paragraphs.



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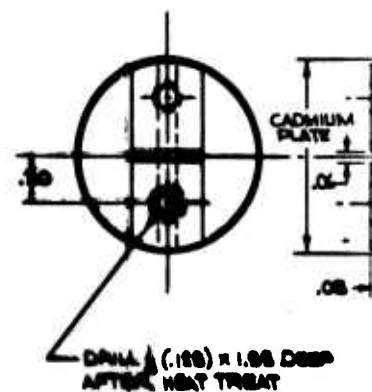
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215-24020 (REF)



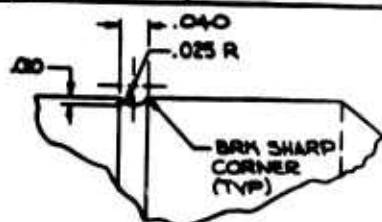
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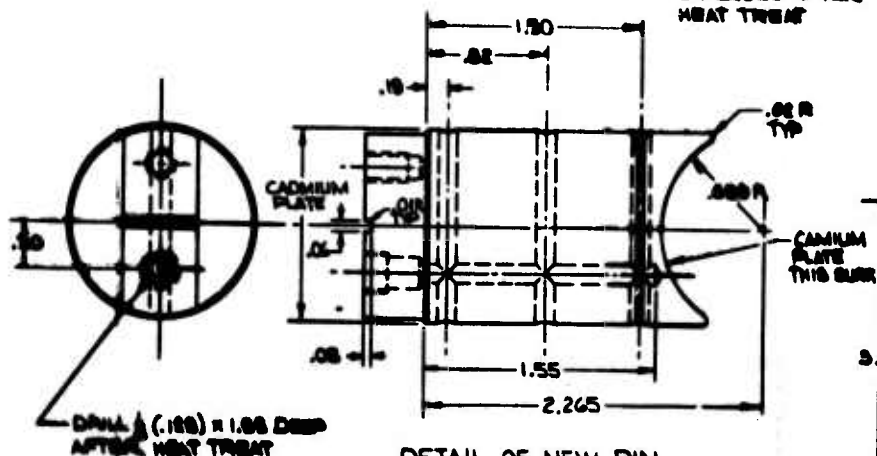
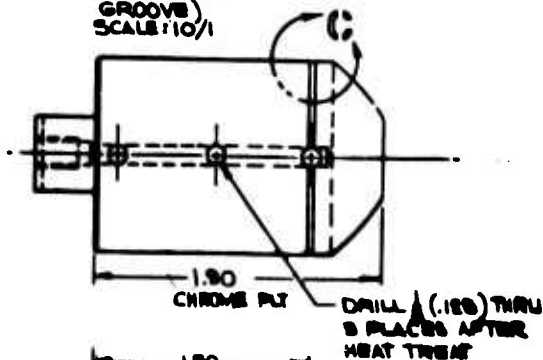
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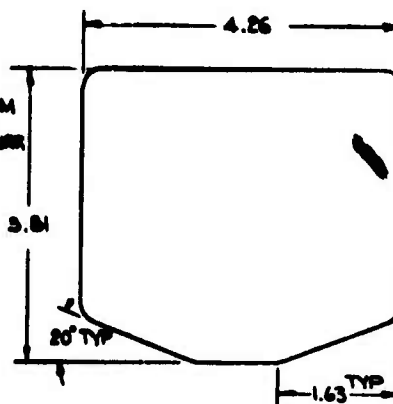
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Figure 13. Item No. 1 - A-7D main landing gear shock and tension strut trunnion and pin assembly.

ITEM NO. 1 - A-7D MAIN LANDING GEAR SHOCK AND TENSION STRUT TRUNNION AND PIN ASSEMBLY

PROBLEM:

Galling and corrosion of pin on lower trunnion bearing surface.

CAUSE:

Drainage of dirty water from the aft bulkhead of the main wheel well and support fitting can enter trunnion bearing surfaces through openings on the upper surface of the fitting and settle in the small gap between the pin and trunnion on the lower side. Water carried grit, which, during taxiing and takeoff/landing operations on rough runways, erodes the chrome surface of the pin and the unprotected surface of the trunnion material.

LOW-COST DESIGN (See Figure 13):

1. Cover openings on upper trunnion surface with a metal cap which is fastened to trunnion.
2. Provide additional passageways in pin to allow grease from existing lubricating system to be applied to pin/trunnion bearing surfaces to provide a barrier to grit which can possibly enter from underneath trunnion during taxi on wet runways.
3. Provide a dry lube surface on trunnion bearing area, either cadmium plate or dry lube.
4. Bearing stresses may be reduced by adding approximately 20 percent to the bearing width on the aft side of the trunnion fitting and by reshaping the inner end of the pin to add more bearing surface on the upper and lower sides of the trunnion hole.
5. Existing trunnion fittings which have galled or damaged bearing surfaces may be salvaged by reaming out the damaged area and plating or flame spraying to build up the area sufficiently for rehonning the hole to proper diameter. Existing fittings are currently discarded and replaced.

#### ITEM NO. 4 - F-4 FUSELAGE FUEL TANKS REINFORCEMENT LINER SKINS

##### PROBLEM:

The present F-4 fuselage fuel tank floors consists of zee frames covered with 0.032- and 0.040-inch-thick aluminum floor skins and closed out on the lower side with an engine compartment insulation shroud. No fore and aft stiffeners (intercostals) are used.

Fatigue cracks have developed in the floor skins of fuselage fuel tanks 3, 4, 5, and 6 on numerous F-4 aircraft. The cracks tend to develop along the heel line of the frames and then propagate to the frame. Attach rivets into the areas between the frames. A limited number of cracks have also been experienced in the 0.016-inch aluminum.

##### CAUSE:

Fuel loads due to surge, hydrostatic pressures, maneuvers, etc., in conjunction with shear and vibration loads from the engines, cause repeated cycling of the floor skins between frames until the aforementioned cracks occur. The crack pattern is considered to be a classical example of a fluid overpressure condition. The fuel cavity floor and side wall skins are fabricated from 7178-T6 aluminum material that does not have adequate fatigue resistance.

##### LOW-COST DESIGN:

Two approaches were considered for repair and to prevent future cracks. The first configuration (Figure 14) consists of beaded straps with scalloped edge trims. These straps would be installed over existing station frames and the cracks in question. Existing fasteners would not be disturbed except those used at each end of the new strap. Existing attachment locations may be utilized if strength requirements dictate.

Merit of this repair is its ease of fabrication and installation. Roll-formed straps could be utilized, and a universal size selected for each fuel bay needing repair. The beaded section is used to "bridge" over existing fasteners. All work would be accomplished from the top side of the tank floor, and no floor would need to be removed to install new straps. Due to the design of the straps, existing load paths will not be changed. Installation will be accomplished per T.O. manual methods currently in use regarding bonding, stop drilling of cracks, sealing, finishing, and chafing tape application. Total weight of repair is 2.41 pounds for cell No. 4.



1





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Architectural drawing of a ship's hull section, showing fuel cell locations and structural details. The drawing includes a large curved hull section and a vertical section on the right.

Labels and annotations include:

- FUEL CELL NO. 1
- FUEL CELL NO. 2
- FUEL CELL NO. 3
- FUEL CELL NO. 4
- FUEL CELL NO. 5
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- FUEL CELL NO. 99
- FUEL CELL NO. 100

SECTION 1-1 (SEE 1-1)

SECTION 2-2 (SEE 2-2)

SECTION 3-3 (SEE 3-3)

SECTION 4-4 (SEE 4-4)

SECTION 5-5 (SEE 5-5)

SECTION 6-6 (SEE 6-6)

SECTION 7-7 (SEE 7-7)

SECTION 8-8 (SEE 8-8)

SECTION 9-9 (SEE 9-9)

SECTION 10-10 (SEE 10-10)

SECTION 11-11 (SEE 11-11)

SECTION 12-12 (SEE 12-12)

SECTION 13-13 (SEE 13-13)

SECTION 14-14 (SEE 14-14)

SECTION 15-15 (SEE 15-15)

SECTION 16-16 (SEE 16-16)

SECTION 17-17 (SEE 17-17)

SECTION 18-18 (SEE 18-18)

SECTION 19-19 (SEE 19-19)

SECTION 20-20 (SEE 20-20)

SECTION 21-21 (SEE 21-21)

SECTION 22-22 (SEE 22-22)

SECTION 23-23 (SEE 23-23)

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SECTION 37-37 (SEE 37-37)

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SECTION 39-39 (SEE 39-39)

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SECTION 100-100 (SEE 100-100)

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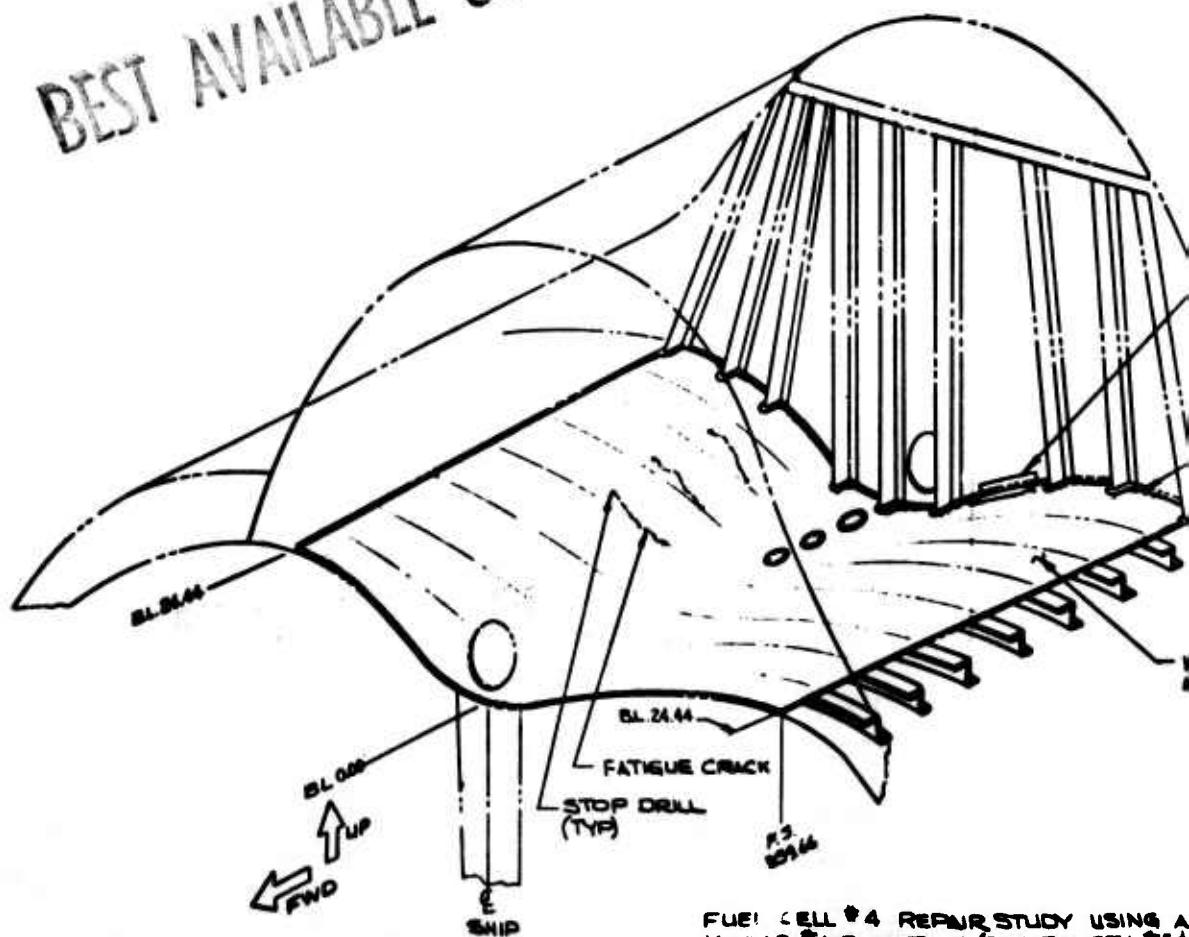






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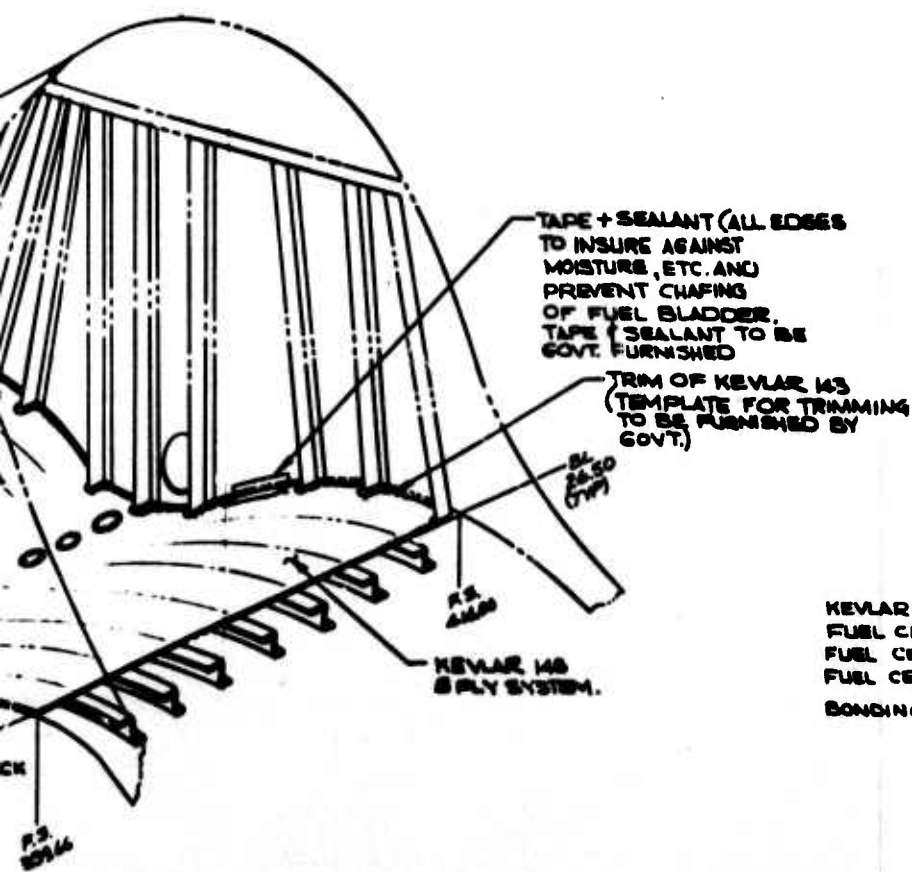


FUEL CELL #4 REPAIR STUDY USING A KEVLAR #143 OVERLAY. (TYP FOR CELL #5) EXISTING FATIGUE CRACKS ARE TO BE STOP DRILLED (SEE ILLUSTRATION) AND STANDARD PATCHING METHODS USED AS REQD. KEVLAR #143 MAY THEN BE APPLIED (SEE VENDOR INSTRUCTIONS) IN A 2 PLY LAMINATE.

FORM 100-1

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KEVLAR SIZES: (3 PLY LAMINATE)  
FUEL CELL #4 62" WIDE X 98" LONG. (WEIGHT OF KEVLAR 14.05<sup>lb</sup>)  
FUEL CELL #3 62" WIDE X 40" LONG. (WEIGHT OF KEVLAR 3.0<sup>lb</sup>)  
FUEL CELL #6 62" WIDE X 40" LONG. (WEIGHT OF KEVLAR 3.0<sup>lb</sup>)  
BONDING MATL WEIGHT 13 POUNDS/SHIP

PL CELL #4 REPAIR STUDY USING A  
PLAR #143 OVERLAY. (TYP FOR CELL #5(46))  
EXISTING FATIGUE CRACKS ARE TO BE STOP-  
PED (SEE ILLUSTRATION) AND STANDARD  
PATCHING METHODS USED AS REQD.  
PLAR #143 MAY THEN BE APPLIED (FOR  
INSTR. INSTRUCTIONS) IN A 3 PLY LAMINATE.

**Figure 14. Item No. 4 - F-4 fuselage fuel tank reinforcement liner skins (concl).**

Kelvar, a high-strength organic material produced by DuPont was considered as a second method of crack prevention (Figure 14). This approach would involve patching cracks that exist using standard localized patching methods found in existing repair manuals and forming a Kevlar composite liner to act as a tension load-carrying member between frames and act to reduce the fatigue stress loads in the aluminum sheet metal skin.

Method of installing Kevlar:

1. After removal of fuel cell bladder and preliminary cleanup, the existing fatigue cracks would be repaired according to the standard repair manual methods.
2. Using a Kevlar unidirectional weave, multiply system, the desired shape is designed to fit the fuel cell floor, including any cutouts for drains, stiffeners, etc. The Kevlar composite material would be in a semiflexible state (0.030 to 0.040-inch thick).
3. Remove foreign material and give fuel cell floor a solvent wipe cleaning.
4. Brush on adhesive (bonding agent) and lay pretrimmed Kevlar in place. Press sheet in place to desired fit and allow to cure for approximately 10 hours at room temperature. After a leak check, the fuel bladder is reinstalled.

A weight comparison between the metallic and nonmetallic (Kevlar) design concepts was made, as shown in the following table:

Repair Concept	Weight of Repair			Total Repair Weight (lb)
	Tank No. 4	Tank No. 5	Tank No. 6	
Metal doubler	2.41	1.75	1.75	5.91
Kevlar	1.77	1.29	1.29	4.35

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#### ITEM NO. 5 - A/T-37 ENGINE TAILPIPE CLAMP

##### PROBLEM:

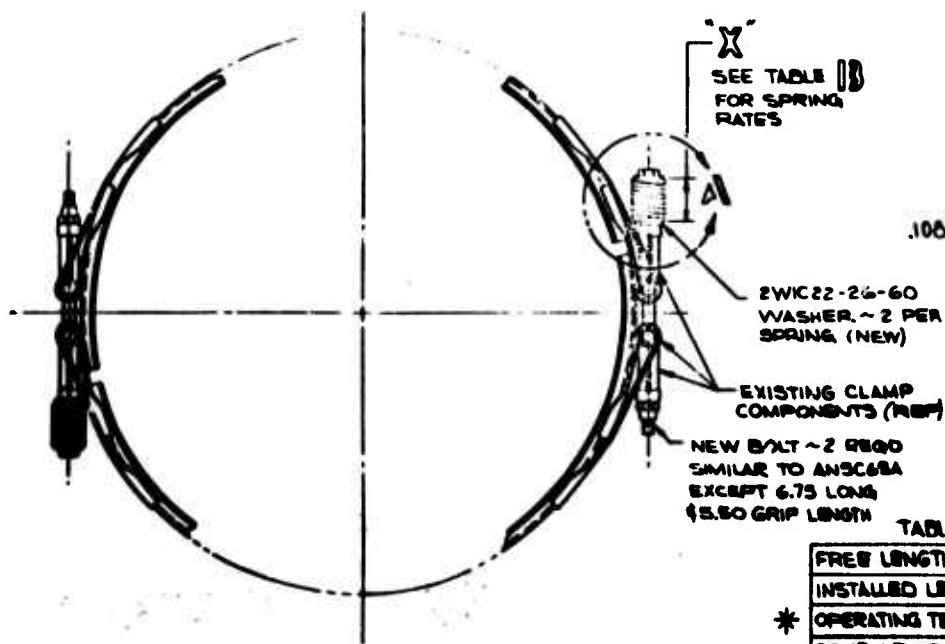
There is a band-type V-section clamp which couples the engine tailpipe to the aft flange of the engine case. It has had a chronic history of breakage. When this occurs, the tailpipe jams the opening in the fairing aft end, causing hot jet impingement on the primary structure. Damage to the structure usually occurs by reduction of allowable strength; however, the extent of damage is difficult to determine. Usually, the structure is replaced when the extent of damage is in question.

##### CAUSE:

The clamp band is in contact with the engine and tailpipe flanges over a very small percentage of its total area. Upon engine start, the engine and tailpipe flanges heat up rapidly and expand. Due to the limited thermal conductivity and transfer, the clamp band does not heat up as quickly, and a high-tension stress is experienced. Yielding of the band material occurs during these thermal cycles until fatigue failure occurs. Existing maintenance instructions specify a maximum clamp bolt torque of 25 inch-pounds upon installation, with no additional tightening during service. Maintenance personnel find clamps that have been stretched and are loose. They usually retorque the bolts again and set up another overstress condition that accelerates the time of clamp failure.

##### LOW-COST DESIGN (See Figure 15):

A spring of suitable strength and deflection may be incorporated into the clamping bolt assembly to prevent overstress of the clamp band when differential heating occurs. A rectangular section compression spring has been designed to serve this function. From existing test data, it has been estimated that a temperature differential as high as 500° F between the engine and clamp can be experienced. This requires 0.11-inch spring deflection in addition to the initial installation deflection. Inconel was selected as the spring material to withstand the maximum operating temperatures and stresses without loss of spring characteristics.



COUPLING \*NH1000850  
(AEROGUHP) WITH ADDITIONAL  
TEMPERATURE COMPENSATOR  
SPRING INSTALLED  
SCALE: 1/2

TABLE 18

FREE LENGTH	1.375
INSTALLED LENGTH	1.117
* OPERATING TEMP LENGTH	.987
SOLID LENGTH	.972

\* BASED ON 500°F TEMP.  
BETWEEN CLAMP AND TAIL



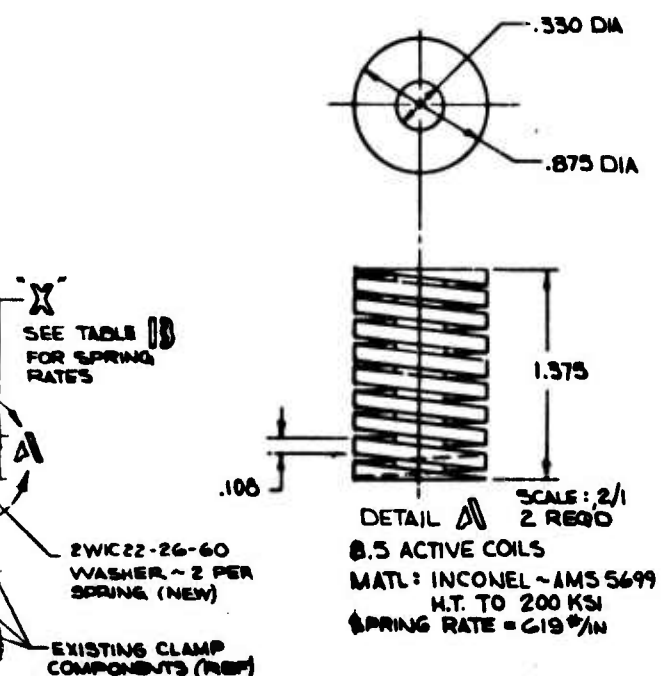


TABLE 18 X BOLT TENSION

FREE LENGTH	1.375	◆
INSTALLED LENGTH	1.117	160*
* OPERATING TEMP LENGTH	.987	240*
SOLID LENGTH	.872	249.5*

\* BASED ON 500°F TEMP. DIFFERENTIAL BETWEEN CLAMP AND TAILPIPE

Figure 15. Item No. 5 - A/T-37 engine tailpipe clamp.

ITEM NO. 3 - T-38 REMOVABLE AFT FUSELAGE FIREWALL ASSEMBLY

PROBLEM:

Damage to the aft fuselage firewall assembly has been occurring during the removal and replacement operation of the aft fuselage section with the center fuselage section. This causes damage to the firewall titanium skin encircling the aft engine area, in the form of dents, gouges, and abrasions. Any gouges or holes require immediate repair, and the lesser types of damage can result in fatigue cracks that require additional repair or replacement of the firewall.

CAUSE:

Damage to the thin titanium firewall sheets is due primarily to contact of engine components due to small engine-to-firewall clearances (reported to be less than one-eighth inch in places). The method of removing and replacing the aft fuselage section, using the component handling trailer No. 3-76500-1, allows significant misalignment between the engine and the aft fuselage section.

The current procedure requires attachment of a clamp mechanism on the main gear struts to prevent their vertical movement. No similar provision is provided for the nose gear. The handling trailer is then positioned beneath the removable aft fuselage section, and the trailer brakes are set. The aft section is then secured to the trailer, and the demating procedure is initiated. As an orientation method for the realignment of the two fuselage sections, a strip of tape is applied across the production break to be used as a visual alignment guide during the remating operation.

The aft fuselage section is manually rolled along the trailer rails (after the disconnect operation is complete) until it is clear of the the engine aft sections. During this operation, the close-tolerance problems are aggravated by improper trailer positioning, wind gusts (causing an abrupt ship-to-trailer misalignment to occur), tire deflection, vertical nose gear strut movement due to a weight transfer caused by the removal of the heavy aft section, and uneven work surfaces between the ship and the trailer (causing centerline-to-centerline discrepancies during the roll-back operation).

During the remating operation, the aforementioned misalignment factors are again experienced, as the trailer operator must visually attempt to realign the tape on the sides of the forward fuselage and the aft section as it is rolled forward.

LOW-COST DESIGN (See Figure 16):

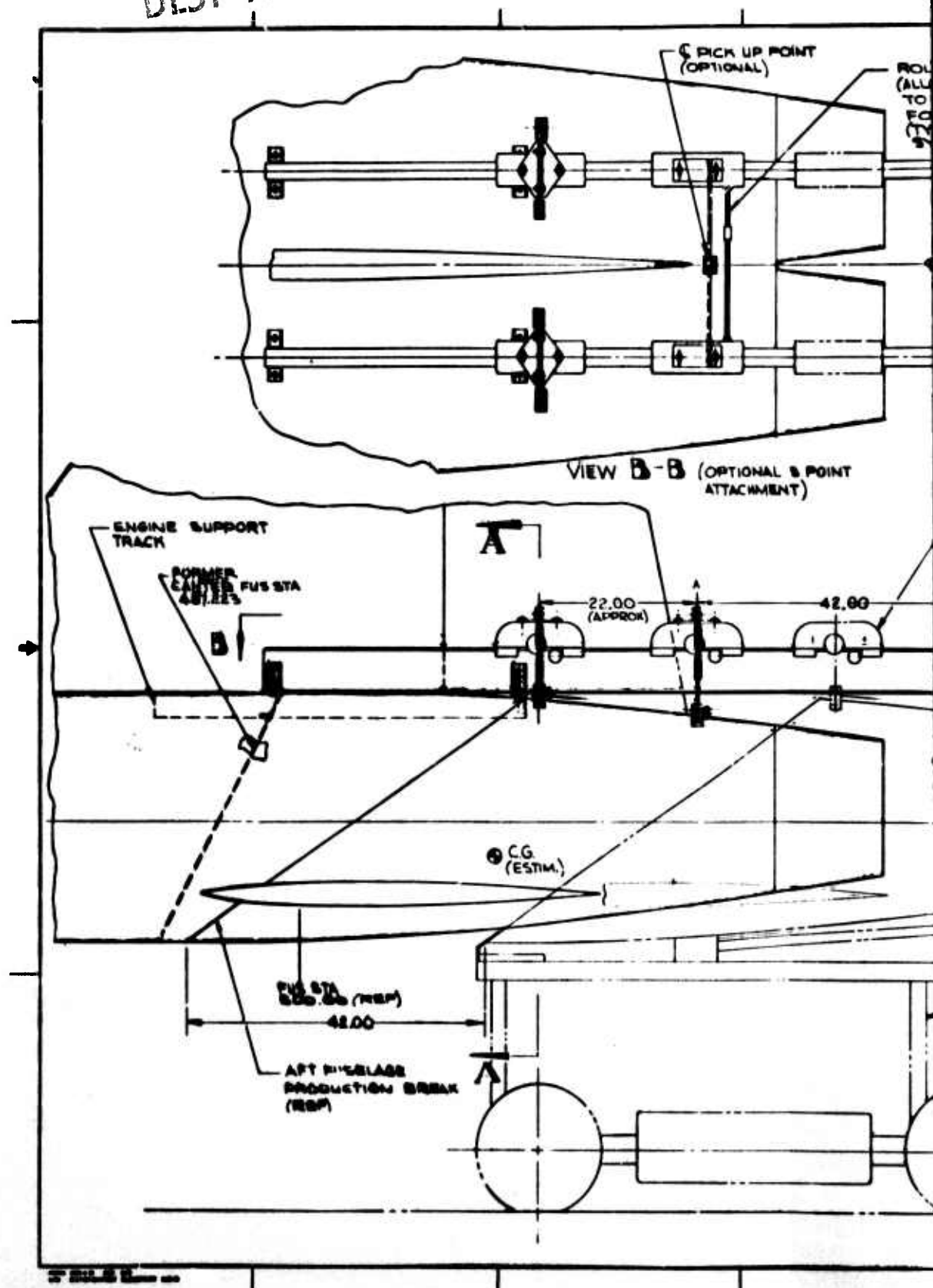
The design study indicates that a supplementary handling guide system can be adapted to the center fuselage section. This guide would be composed of two 6-inch-deep I-beams (aluminum) rigidly attached by removable bolts to existing fuselage hard points; i.e., engine tracks which lie directly beneath the I-beams and existing frames using suitable attachment brackets.

The I-beams would extend approximately 6 feet over the component handling trailer. Four roller adapters (stock items manufactured by the Air Logistics Corporation) would be installed on these I-beams and, using an adjustable yoke system, tie into the aft fuselage section at frame hard points. These tie-in points would have quick-release pull-pins to separate the adapter yokes once the mating and demating operation has been accomplished.

This method would ensure that the aft section would remain in a known reference system in relationship to the center fuselage section while the removal and replacement operations take place. This method allows the aft section to be moved aft approximately 3-1/2 feet before attachment to the component handling trailer. This distance would be ample to provide safe margin and negate the change for firewall damage.

Reversal of the foregoing procedure would be utilized for remating the two fuselage sections. The guide system has the additional merit of a built-in capability that may be utilized to make incremental forward movements during the final mating operation.

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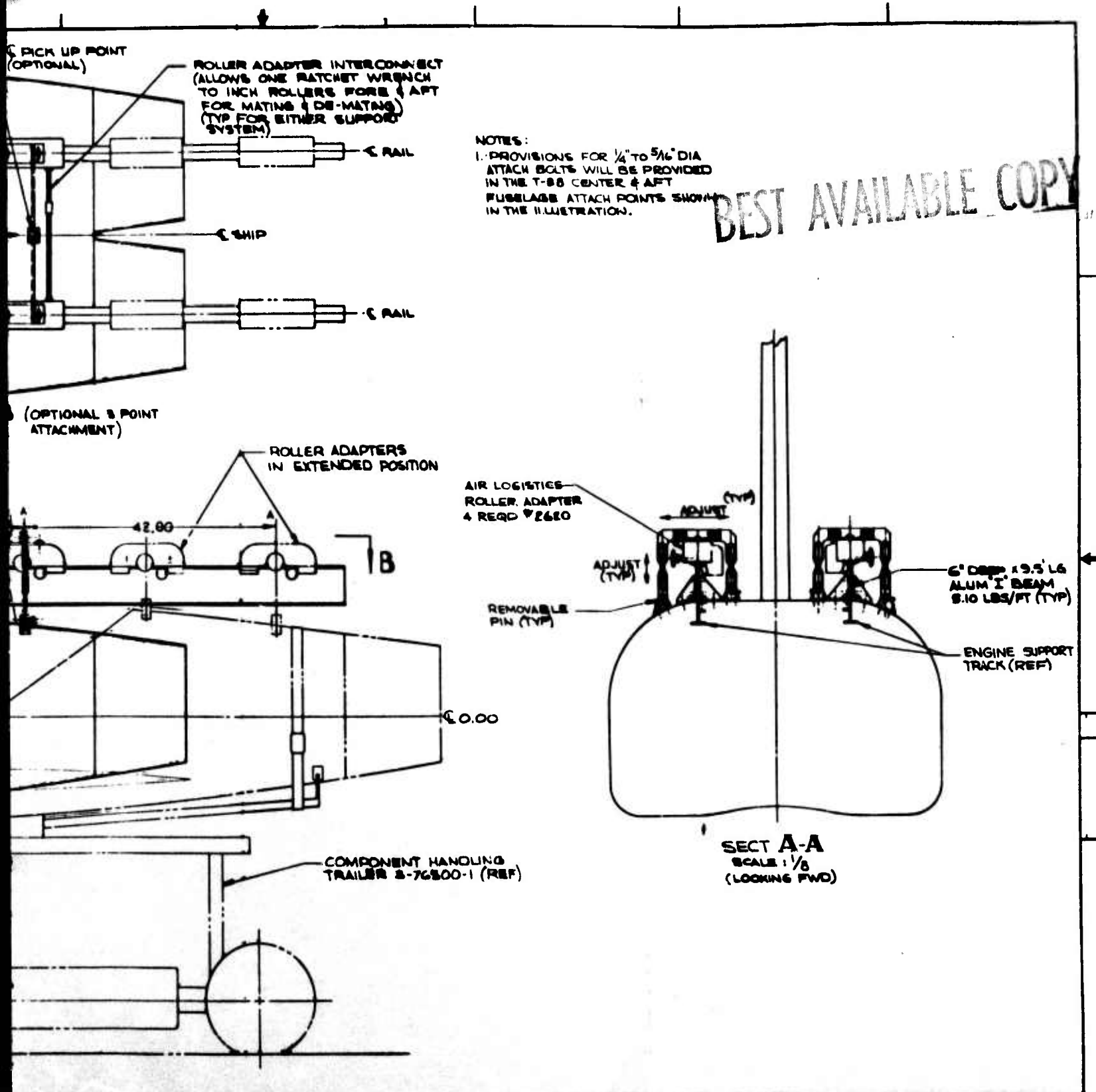


Figure 16. Item No. 6 - T-38 removable aft fuselage firewall assembly.



ITEM NO. 8 - B-52 FORWARD FUSELAGE URINAL AREA

PROBLEM:

Corrosion of structural items (i.e., floor skins, frames, etc) occurs below the urinal and necessitates extensive repairs. The area found to be experiencing the corrosion damage is below the equipment deck, between fuselage stations 267 and 345.5. This area cannot be inspected without removing permanent floor panels or the external fuselage skin. Failure of various elements in the urinal tank assembly itself have also been noted.

CAUSE:

The existing urinal tank is the prime factor in the corrosion problem. Leakage or spillage from the container allows liquid to contact wall panel and floor surfaces, ultimately seeping through floor skins and corroding structural members. In addition to the foregoing problem, servicing of the tank and premature failure of the tank itself have come to light. This is attributed to inadequate design of the urinal tank and its retaining system. Improper servicing methods and carelessness are considered to be the primary cause of spillage.

LOW-COST DESIGN (See Figures 17, 18, and 19)

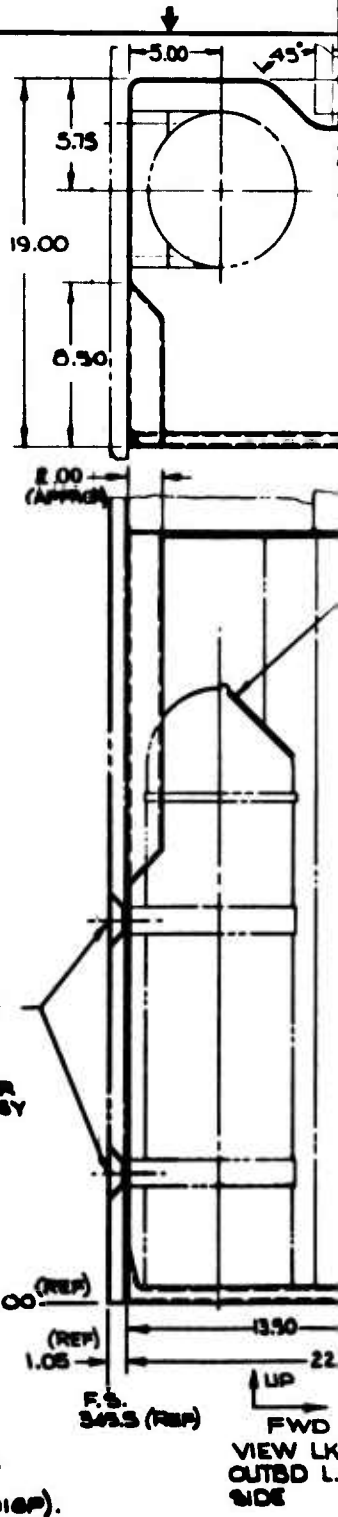
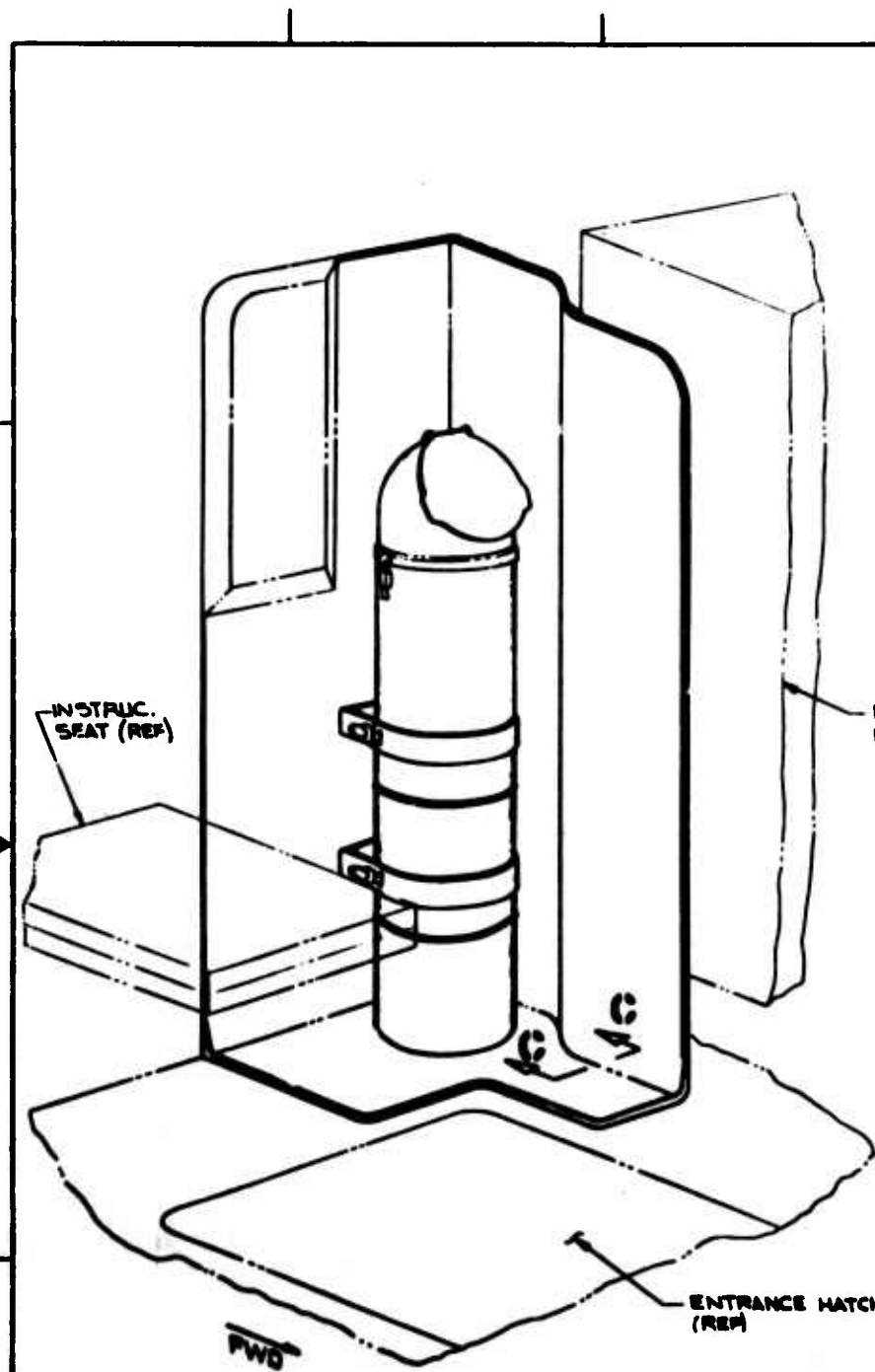
As a prevention against corrosion caused by moisture in the urinal area of the B-52D, the wall and floor area behind and below the urinal tank assembly would be covered with a protective shield and floor pan. The wall shield would be localized (extend several inches either side of the tank), and the floor pan would cover from wall to wall. These items may be fabricated from fiberglass. The wall shield would pick up convenient existing fasteners and extend up and under the existing electronic bay fiberglass cover. The lower edge of the wall shield would joggle over the flange of the floor pan to prevent any joint leakage and to eliminate use of fasteners that would create additional leak paths.

The floor pan would extend from the vertical shield across to the opposite wall, and fore and aft from the vertical face of the forward entry hatch frame, back to the auxiliary crew seat. In the walkway area, a beaded section would extend from the corner of the electrical bay diagonally outboard to the vertical face of the forward raised floor area. The perimeter of the floor pan would incorporate a vertical lip section to retain any moisture and to clear existing attachments in the floor edge members.

As a prevention against corrosion caused by moisture in the urinal area of the B-52G and H models, a one-piece molded fiberglass stall would be required. It would consist of two vertical walls (right and rear) plus a floor panel. The one-piece design would prevent joint leakage. As a further precaution against leakage and corrosion points, the stall would be fastened with Velcro tape to existing structure.

The floor pan would have a beaded section along its free edge high enough to retain excess moisture and would be shaped to allow clearance around the main entry hatch opening.

The urinal tank assembly would be restrained against the rear wall, using the existing brackets. These attachments would be sealed with a leakproof corrosion material.

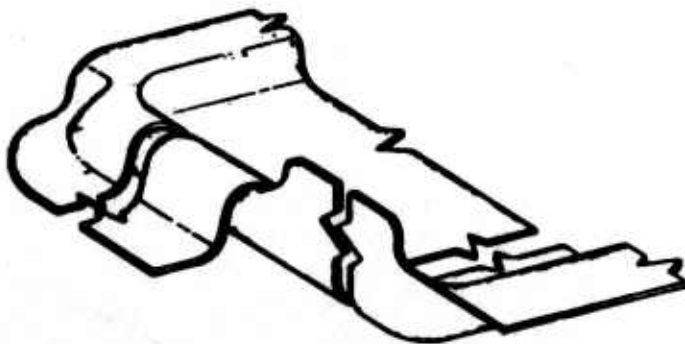


NAS603-4  
AN970-3  
(EXISTING  
ATTACH)  
4 PLCS FOR  
URNAL ASSY  
TIE DOWN

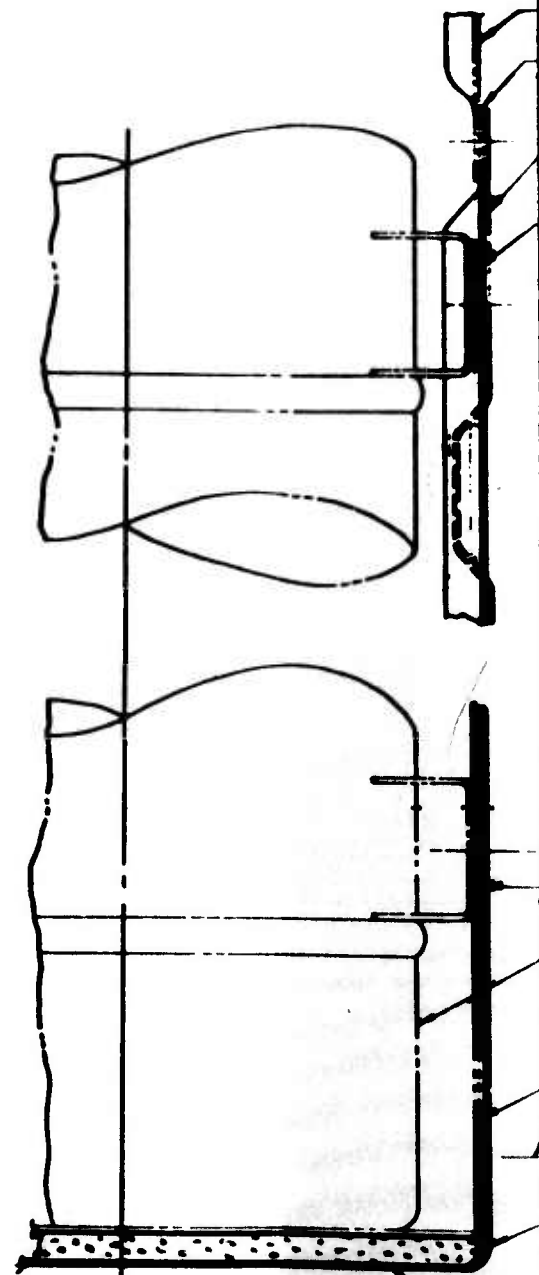
W.L. 114.00 (REF)  
(REF)  
1.05  
F.S.  
342.5 (REF)

- NOTES:
1. MATERIAL FOR -003 STALL TO BE EPOXY PREIMPREGNATED GLASS FABRIC . 5/32" THK PER STERISOL-600 TYPE I (REF VOL. 13 OF MIL STD DESIGN PRACTICES, SHT 6 OF SI 9565-00010P). -003 TO BE FABRICATED IN ONE LAYUP IF POSSIBLE (FLOOR & TWO SIDES)
  2. ATTACH PROTECTIVE SHIELD TO AIRCRAFT STRUCTURE USING VELCRO TAPE. APPLY VELCRO IN SUFFICIENT QUANTITY TO RETAIN SHIELD DURING FLIGHT CONDITIONS.





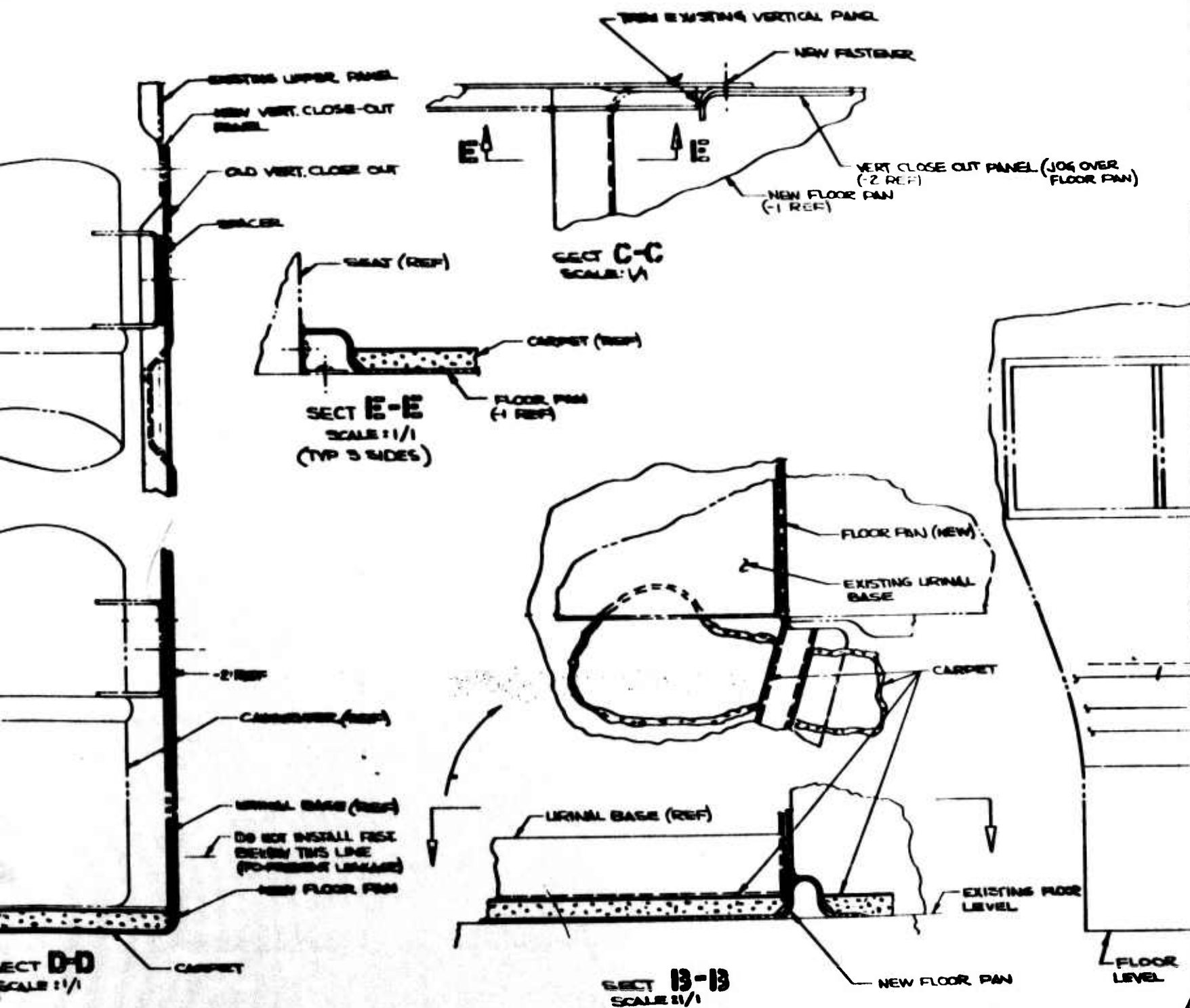
**DETAIL F**  
 (FLOOR PAN DETAIL ONLY)  
 (-1 REF)



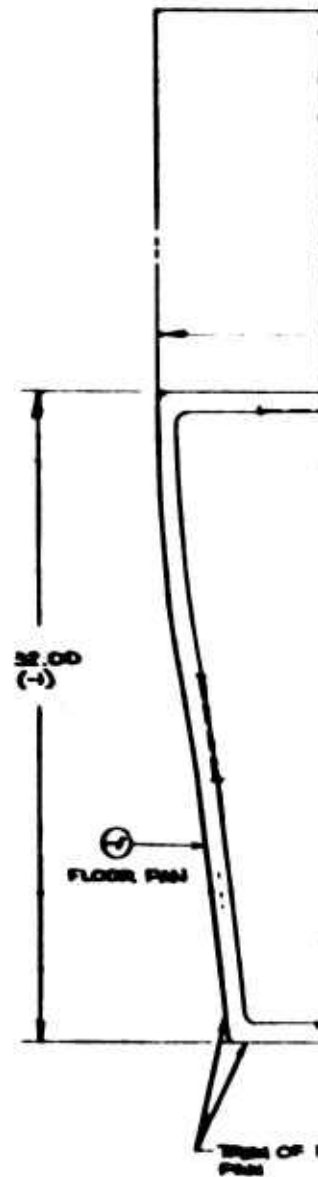
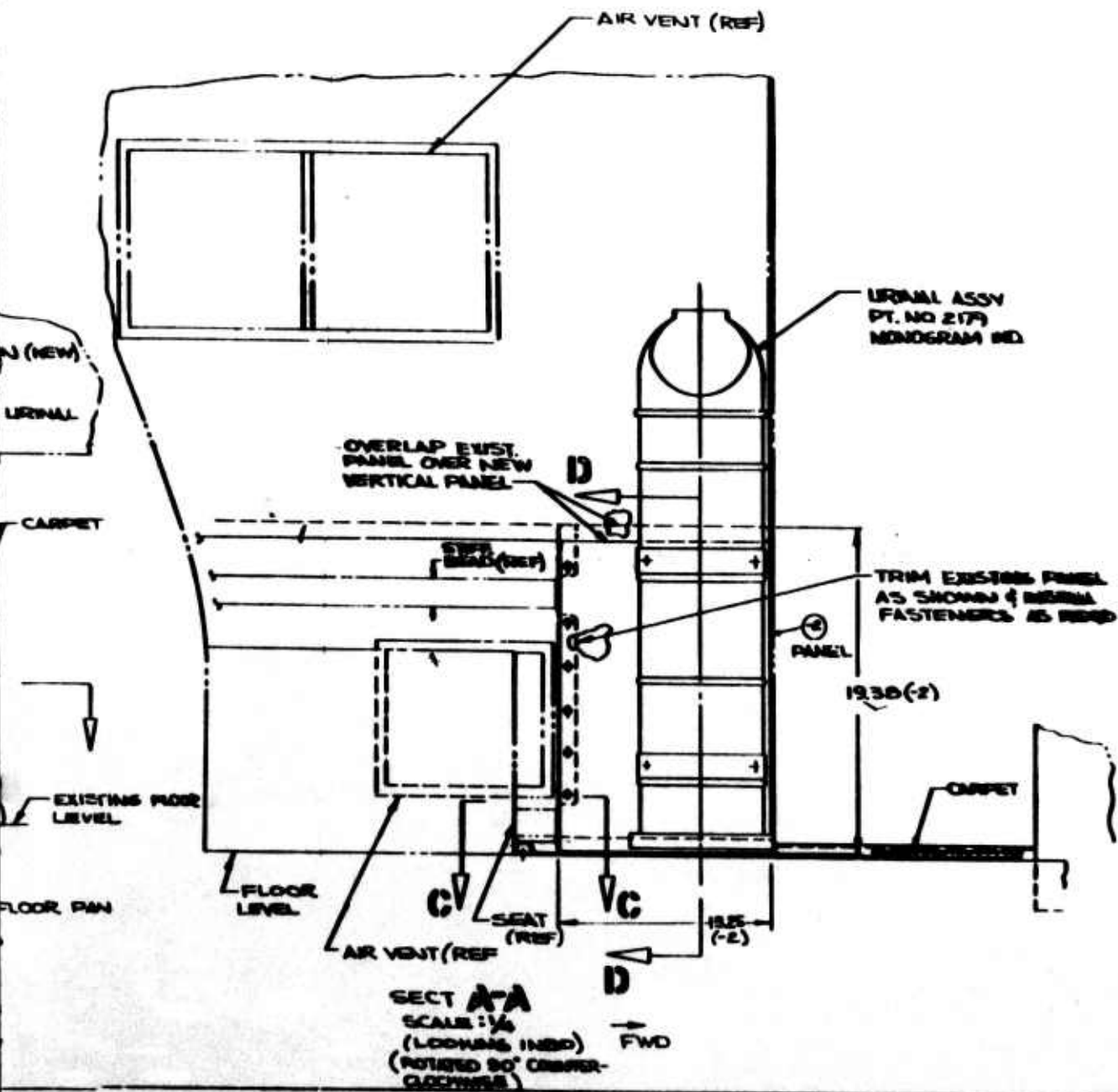
**SECT D-D**  
 SCALE 1/1

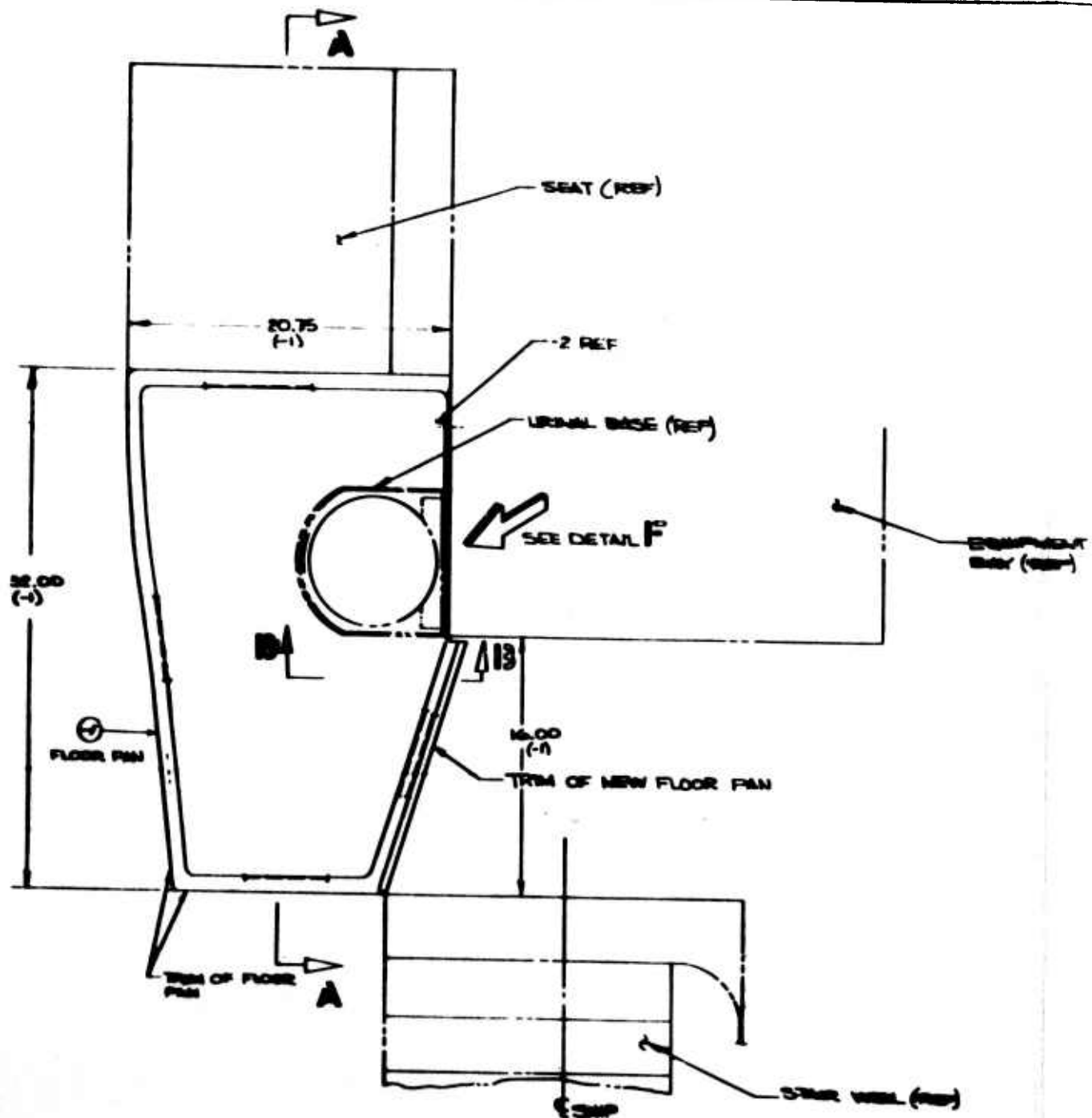
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LOSE OUT PANEL (JOG OVER FLOOR PAN)





↓  
FWD

VIEW LOOKING DOWN  
SCALE : 1/4"  
(SCALE DIMS FOR  
DIM. NOT SHOWN)

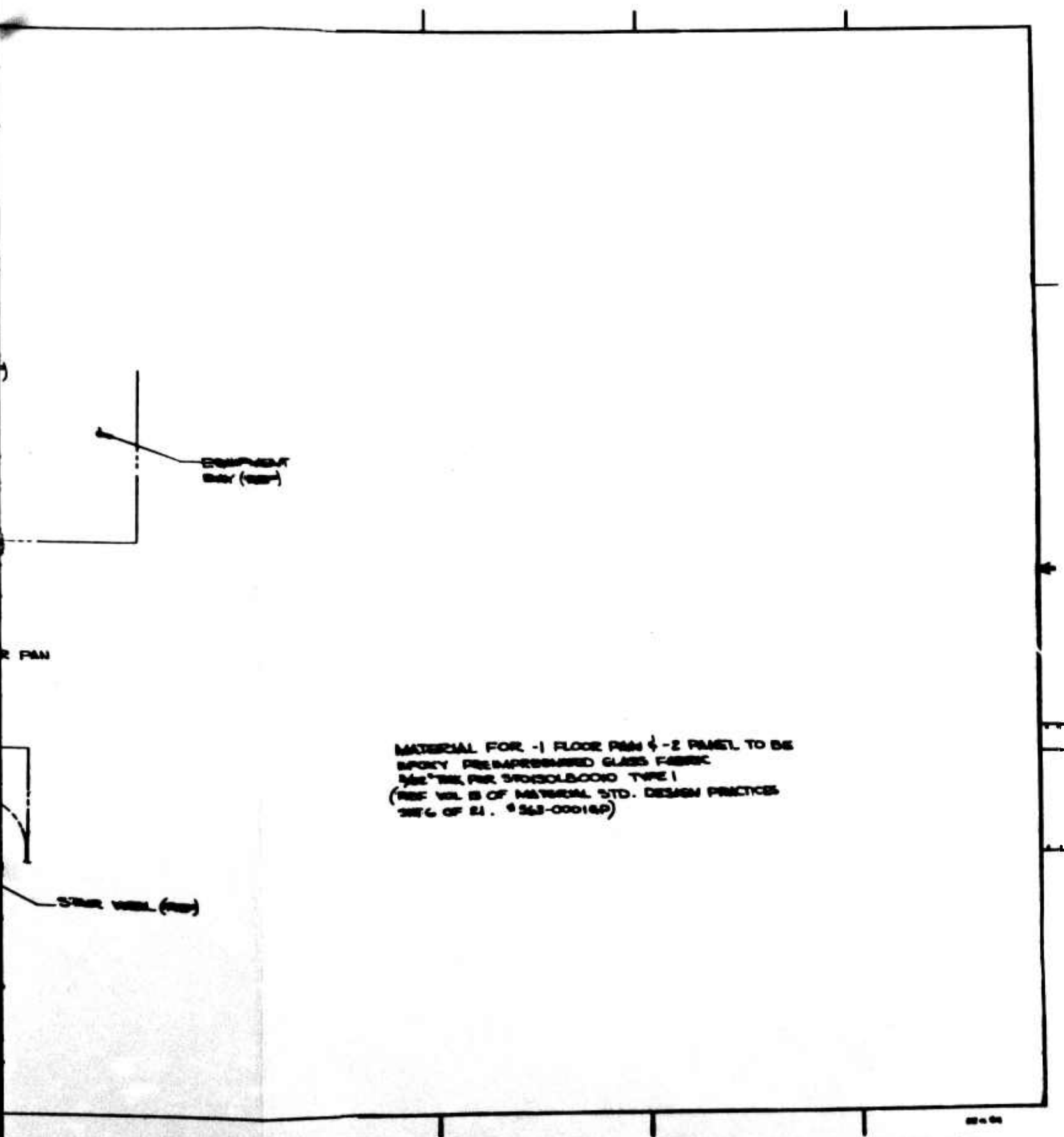
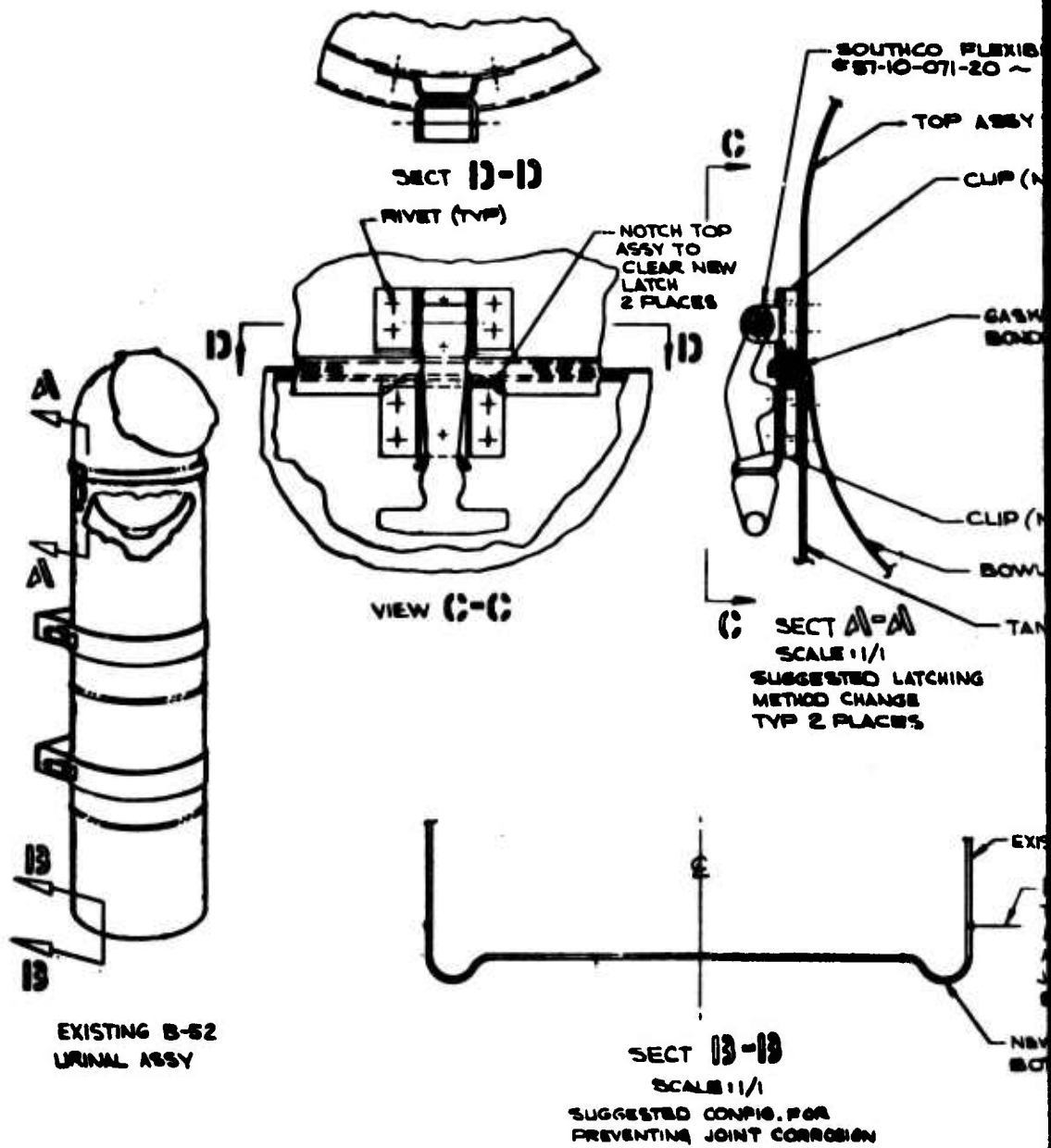


Figure 18. Item No. 8A - B-52D forward fuselage urinal area.





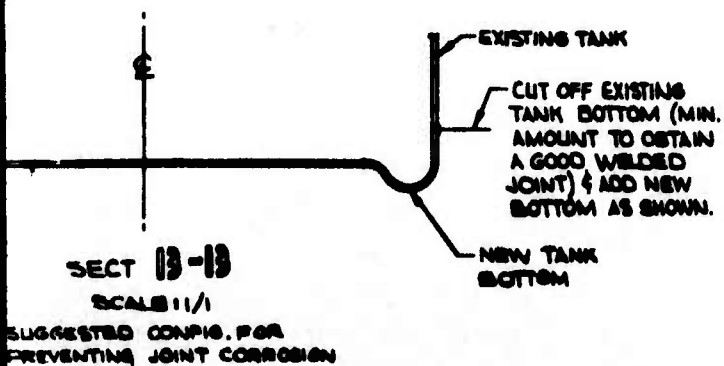
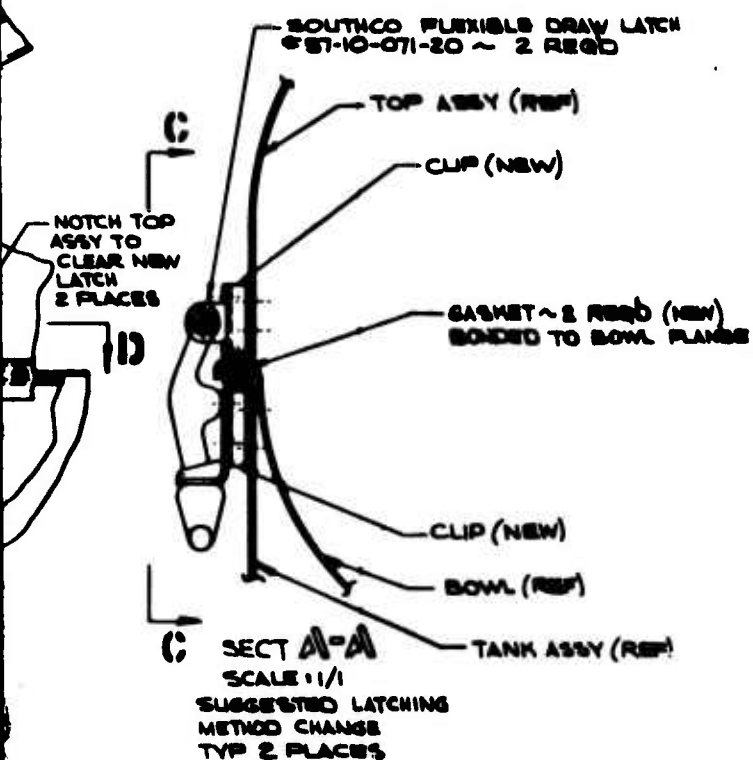
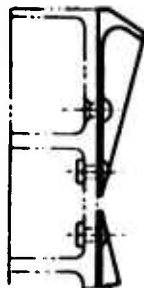


Figure 19. Items No. 8A and 8B - B-52 forward fuselage urinal.

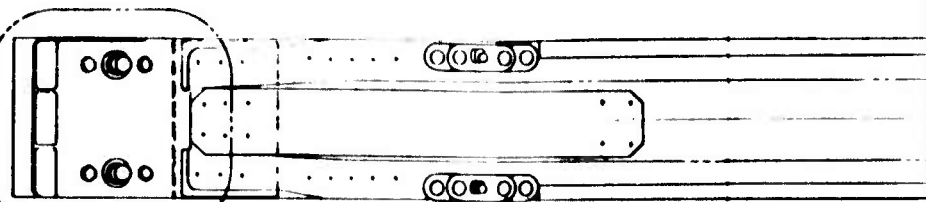


1W5H 572  
20.757

DIRECTION  
OF ADJ.

SEE DETAIL  
FOR NEW DOOR  
GUIDE INSTL  
(TYPICAL FOR  
SLAT ACTUATOR  
DOOR ASSYS  
1A THRU 5B)

DETAIL (C) (SEE NOTE A)  
OPTIONAL DESIGN  
TO FACILITATE INBD  
& OUTBD ADJUSTMENT  
OF GUIDE



DOOR ASSY-SLAT ACTUATOR, TRACK 1A  
VIEW LOOKING INBD PARALLEL TO  
THE INNER WING SLAT HINGE LINE

SCALE: NONE

2 GUIDE  
7878-76 AL ALY  
CASTING  
HARD ANNEAL  
(TYP FOR OPTIONAL  
CONFIGURATIONS)

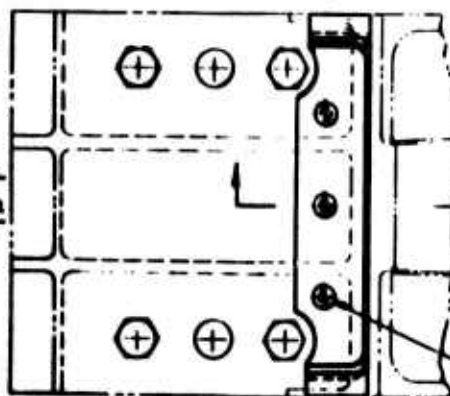
SEE DETAIL (C)

FLUSH  
RIVETS  
IN THIS  
AREA OPT.  
TO CLEAR  
ADJ. PTS.

OPTIONAL  
SHAPE  
TO CLEAR  
SLAT ACTUATOR

30" (TYP)  
.09  
.09 (TYP)

SECT 12-13



DETAIL (C)  
SCALE 11/1  
INBD  
OUT

BLIND RIVETS  
IF NEEDED FOR  
INSTL WITHOUT  
DOOR REMOVAL  
& REGRIND

NOTE A. TWO OR MORE GUIDES MAY  
BE CAST AS ONE PIECE TO  
BE MACHINED APART BEFORE  
INSTL.

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ITEM NO. 9 - C-5A WING LEADING EDGE SLAT ACTUATOR DOORS

PROBLEM:

High maintenance man-hours are being experienced at operational bases on the subject doors to replace failed parts in the mechanism and to keep the doors adjusted for proper alignment with the opening in the wing structure. Failures are occurring in the spherical head adjustment fittings due to tension failure at the base of the head or by pulling the threaded inserts out of the slat track fitting.

CAUSE:

The cause of these failures has been analyzed to be an excessive load induced during slat retraction when the door misaligns with the door jamb on the wing structure before the slat has completed its retraction. Misalignment may occur from the following conditions:

1. Initial maladjustment
2. Airload deflections
3. Excessive play in the mechanism
4. Slippage of the ball joint fittings, relative to the door, due to loose bolts that clamp them to the door through a slotted hole
5. Broken attach links or adjustment fittings
6. Pulled thread inserts in the slat track attach fittings

LOW-COST DESIGN (See Figure 20)

Addition of self-aligning ramp guides to each side of the doors at the forward and aft ends to bring it into alignment with the jamb for proper seating during retraction and prevent a misaligned door from catching on the structure.

An additional recommendation is that a review be made of the kinematics of the subject door actuating mechanism to redesign the adjustment links and fittings to permit use of one standard-size spherical head link that would eliminate the possibility of installation of a link with insufficient length of thread engagement. This would reduce the failure rates for the door assembly.

ITEM NO. 10 - C-5A ENGINE COWL DOOR HINGE FITTING

PROBLEM:

The powerplant cowl door hinge fitting at station 179.000 has experienced numerous structural failures in the small-radius flange area closest to the cowl door. The crack on the cowl hinge fitting under study extends diagonally across the inner fillet radius for approximately 3/16 inch and is readily visible to the naked eye.

CAUSE:

One of the more apparent causes of the cracked fitting is overextension of the cowl door during maintenance operations. This allows the adjacent cowl structure to bottom out against the hinge fitting, thereby inducing bending stresses capable of failing the area in question.

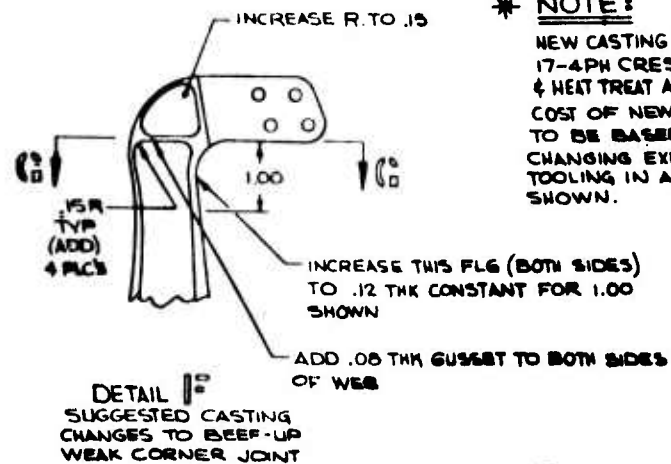
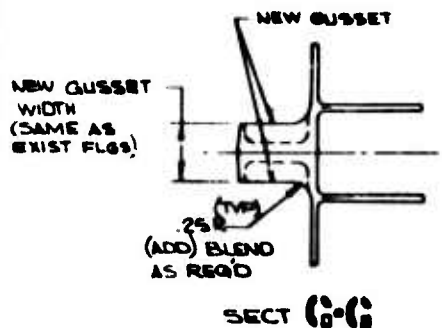
Another factor capable of causing the cracked hinge fitting failure may be excessive loads induced by wind gusts when the door is in its open position. A tension load in the hinge fitting would occur due to the door strut geometry in the open position.

LOW-COST DESIGN (See Figure 21)

Two approaches to the cracked fitting were considered. The first was a new fitting with an adequate beefup of the flange area. The increased thickness of the flanges and the addition of gussets would insure adequate load paths for momentary high stress loads the fitting may experience.

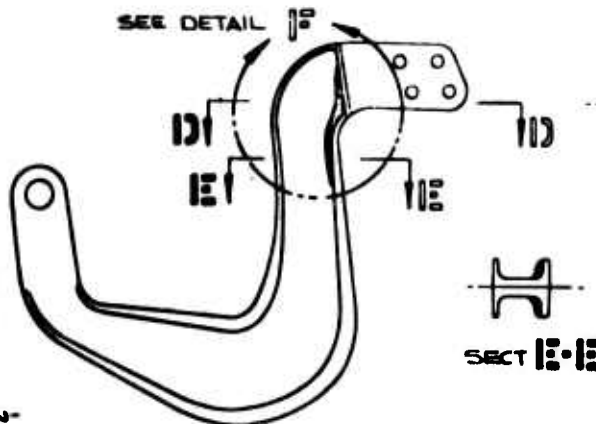
An alternate approach considered was reinforcement of the crack-prone area by welding. The flanges on either side of the critical area could be built up with weld until the cross-sectional area is large enough to withstand higher stress loads. This method may also be used to repair cracked fittings.



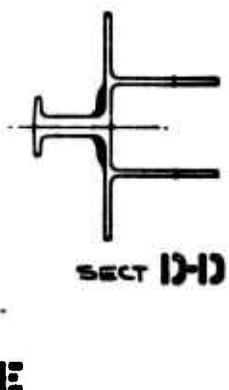


\* **NOTE:**  
NEW CASTING TO BE 17-4PH CRES (SAME MAT'LTY & HEAT TREAT AS ORIG. PART). COST OF NEW CASTING TO BE BASED ON CHANGING EXISTING TOOLING IN AREA SHOWN.

- PREPARATION OF HINGE FTS. PRIOR TO WELDING & WELDING PROC.
1. CLEAN FTS. USING SOLVENT & EMULSION CLEANING METHODS.
  2. ANNEAL FTS. AT A TEMP OF 1900  $\pm$  25  $^{\circ}$ F FOR MAX OF 45 MIN. USING A ARGON, HELIUM OR DRY HYDROGEN ATMOSPHERE OR VACUUM FURNACE.
  3. APPLY SCALE INHIBITING COMP. .0005 THK TO PREVENT OXIDATION DURING ANNEALING.
  4. BLEND OUT CRACKS INSURING NO PART OF CRACK REMAINS. USE 60  $^{\circ}$  VEE GROOVE IF POSSIBLE.
  5. WELD THE CRACK (S) USING TUNGSTEN-ARC WELDING PROCESS (17-4PH CRES STEEL WIRE, VACUUM MELTED).
  6. BUILD UP WELD PER VIEW C-C & AND GRIND AS REQ'D FOR INST. OF PART.
  7. REPEAT STEP #1 (CLEANING)
  8. RADIOGRAPHIC INSPECT HINGE
  9. REPEAT ANNEAL STEP #2
  10. PRECIPITATION HARDEN FTS TO COND H925, SPEC STPS4-G13 (LOCKWED)
  11. PASSIVATE FTS BY IMMERSION FOR 30 TO 60 MIN IN SOLUTION OF 60 TO 70 GSS. OF FES. SPEC G-N-50 NITRIC ACID IN ONE GAL OF H<sub>2</sub>O AT A TEMP OF 150  $^{\circ}$ F. & DRY.



**VIEW C**  
SCALE: 1/1  
SUGGESTED METHOD OF SALVAGING EXISTING COWL HINGE BY INCREASING CROSS SECTIONAL AREA USING WELD BUILD-UP. (SEE DARKENED AREA IN ILLUSTRATION)



**DETAIL I-I**  
COWL HINGE

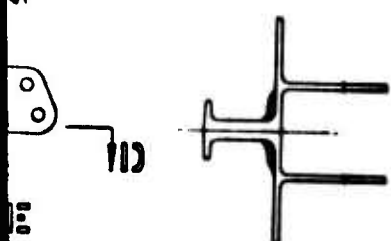
INCREASE R. TO .15

\* NOTE:

NEW CASTING TO BE  
17-4PH CRES (SAME MATL TYPE  
& HEAT TREAT AS ORIG. PART).  
COST OF NEW CASTING  
TO BE BASED ON  
CHANGING EXISTING  
TOOLING IN AREA  
SHOWN.

INCREASE THIS FLG (BOTH SIDES)  
TO .12 THK CONSTANT FOR 1.00  
SHOWN

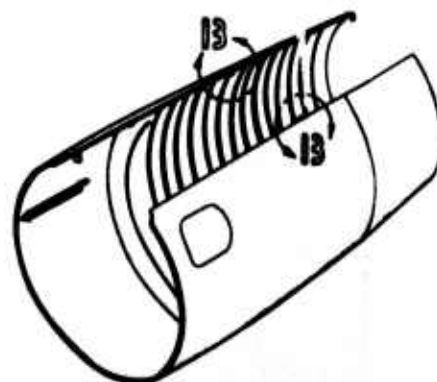
ADD .08 THK GUSSET TO BOTH SIDES  
OF WEB



SECT 12-13



SECT 12-13



DETAIL A  
POWER PLANT  
COWL DOOR (TYP)



DETAIL 13  
COWL HINGE

Figure 21. Item No. 10 - C-5A engine cowl door hinge fitting.

2

ITEM NO. 13 - C/KC-135 INNER TO OUTER WING JOINT RIBS

PROBLEM:

Severe surface corrosion has been encountered in the bathtub pockets in the wing joint rib around attach bolts. The bolts and nuts have also been highly corroded. This condition is prevalent primarily on the upper bolting rib caps.

CAUSE:

Leakage of water and anti-icing fluids around the rib joint cover fairing allows moisture to collect in the pockets of the bolting fittings. No provision has been made for drainage or sealing of the area.

LOW-COST DESIGN (See Figure 22)

The fairing cover has been designed to provide an adequate seal. A Mylar-type gasket would be cemented to the fittings covering the bathtub recesses so that moisture would be prevented from entering the cavities.

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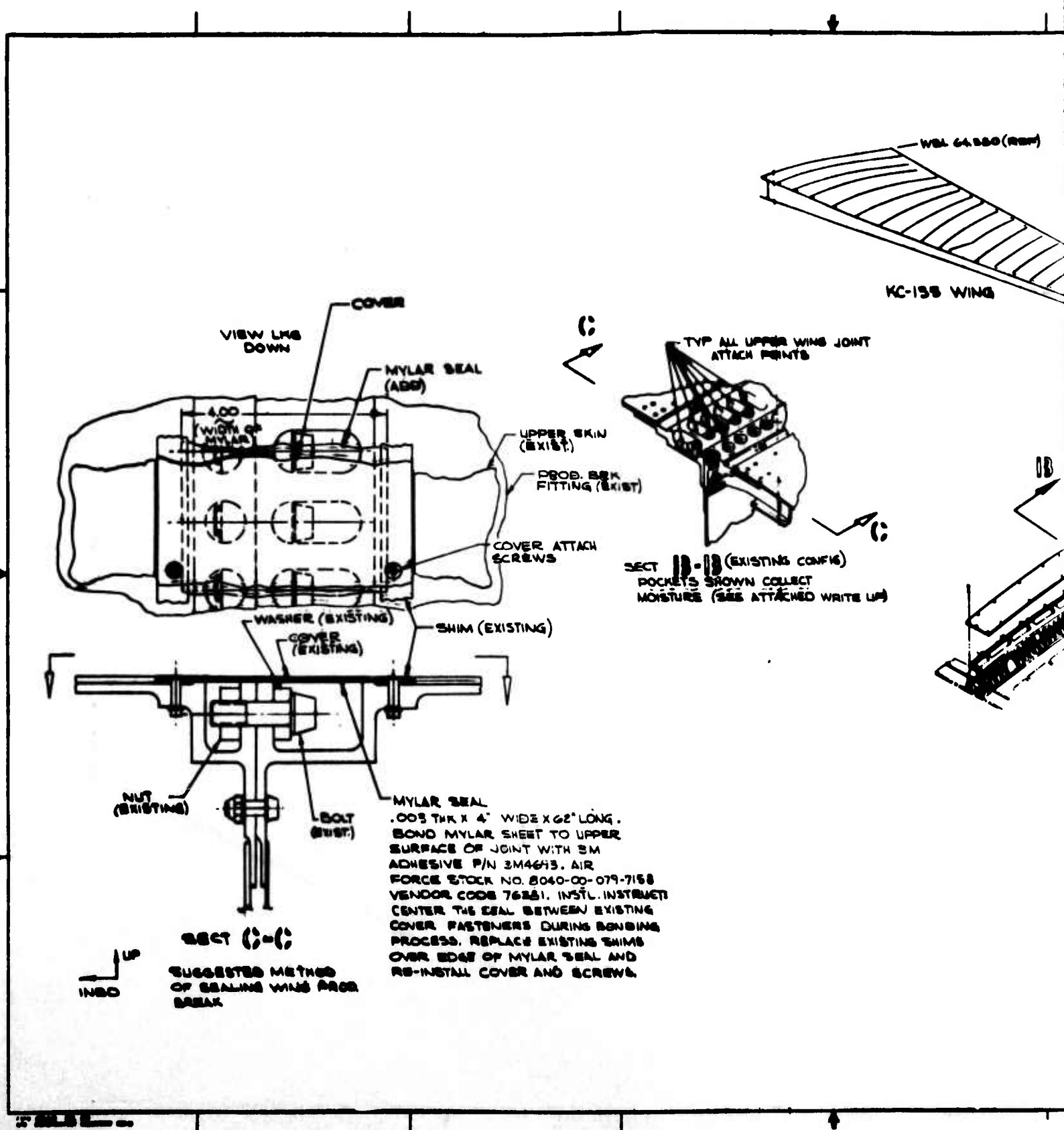
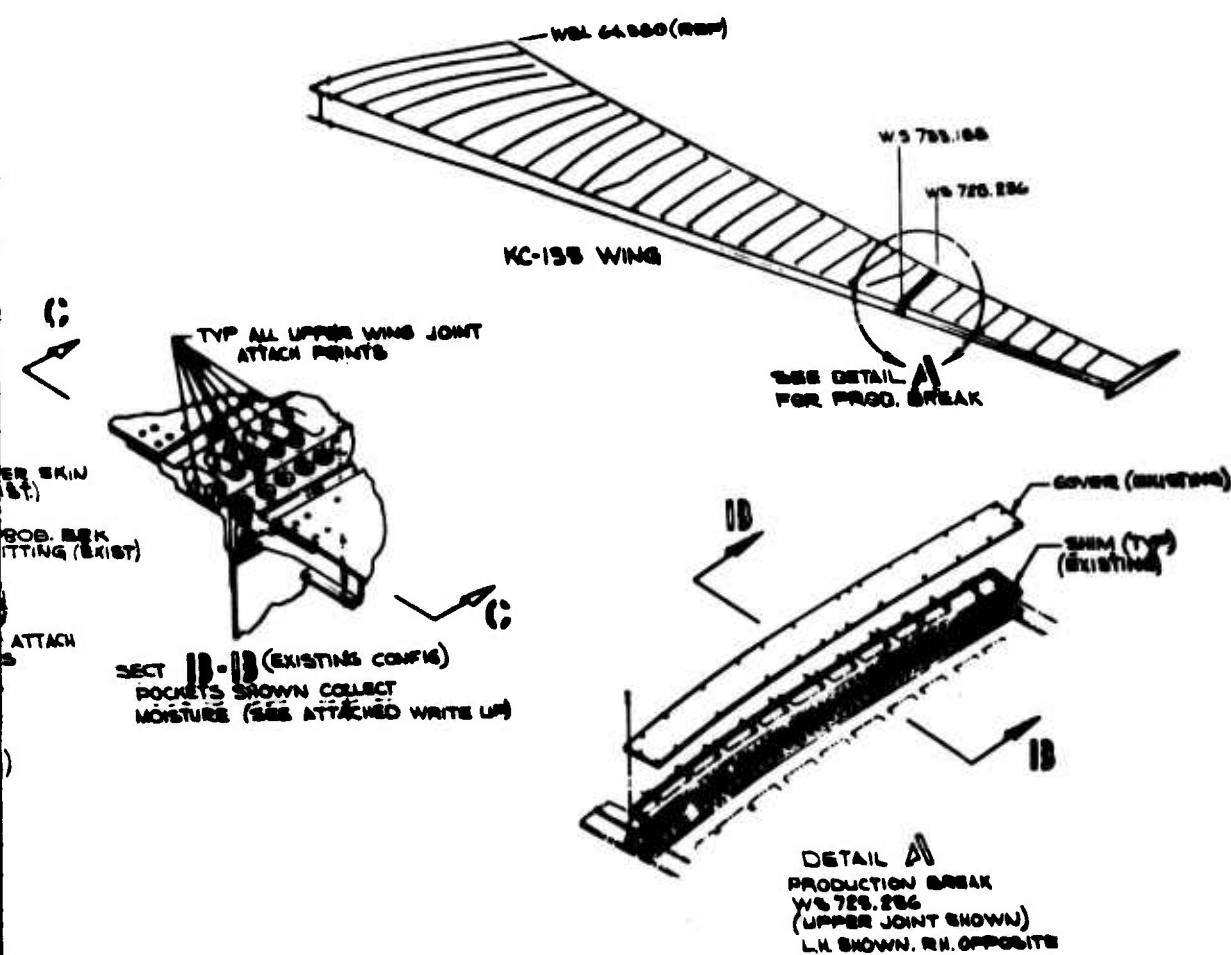


Figure 22



62" LONG.  
TO UPPER  
WITH SM  
3. AIR  
40-00-079-7158  
1. INSTL. INSTRUCT  
BETWEEN EXISTING  
DURING BONDING  
EXISTING SHIMS  
R SEAL AND  
NO SCREWS.

Figure 22. Item No. 13 - C/KC-135 inner to outer wing joint ribs.



ITEM NO. 14 - C-141A ENGINE NACELLE AFT COWL

PROBLEM:

The engine nacelle aft cowl has experienced structural failure of its longitudinal vane assembly and associated inner and outer cap angles. This failure has been in the form of fatigue cracks in the vane assembly and in the corners of the cap angles. Damage in the form of delamination of the honeycomb core has also been found in the area of the outer vane assembly attach members.

Repair of the foregoing damage is tedious and, if extensive enough, requires special tooling to maintain door configuration during repair. Accessibility is the prime problem encountered in repairing the area. Replacement or repair of the vane assembly and caps from either end of the cowl door is limited to the extent a man can reach into the openings. Repair beyond the end areas entails extensive door disassembly at a major repair depot.

The outer honeycomb panel is not removable, and repairs must therefore be made from the inner surface. This is hampered by a lack of easily removable sections of structure to expose the damaged area.

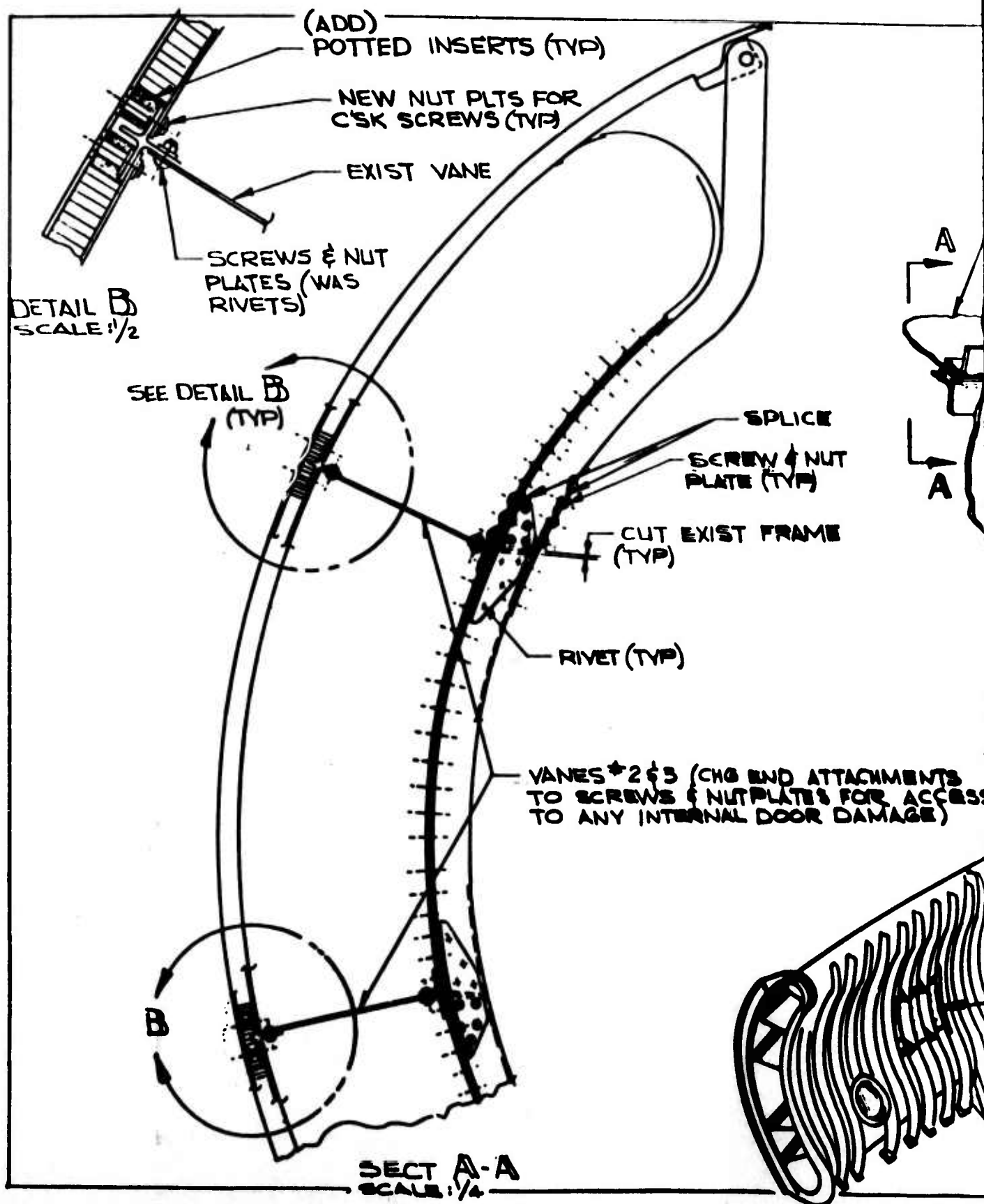
CAUSE:

Repeated cycling of the inner and outer door panels due to airloads and sonic vibration causes working of the vane assemblies and their inboard and outboard attach members, resulting in fatigue cracks.

The constant-tension load in the vanes also causes delamination of the honeycomb panel at the vane outer attach member, which is bonded integrally into the honeycomb panel.

LOW-COST DESIGN (See Figure 23)

Access to areas of the duct, unreachable from either end, is mandatory for repair of the vanes and their attachments. Provisions for two small removable doors in the inboard duct wall structure can be made. These doors would be between the two main vanes and between stations 120.130 and 132.320 for the forward door, and between stations 147.950 and 159.950 for the aft door. The two intermediate frames in each case would require removable splice joints at the upper and lower edges of each door. Sections of each vane in the proximity of each door must also be made movable for access into the upper and lower sections of the duct.



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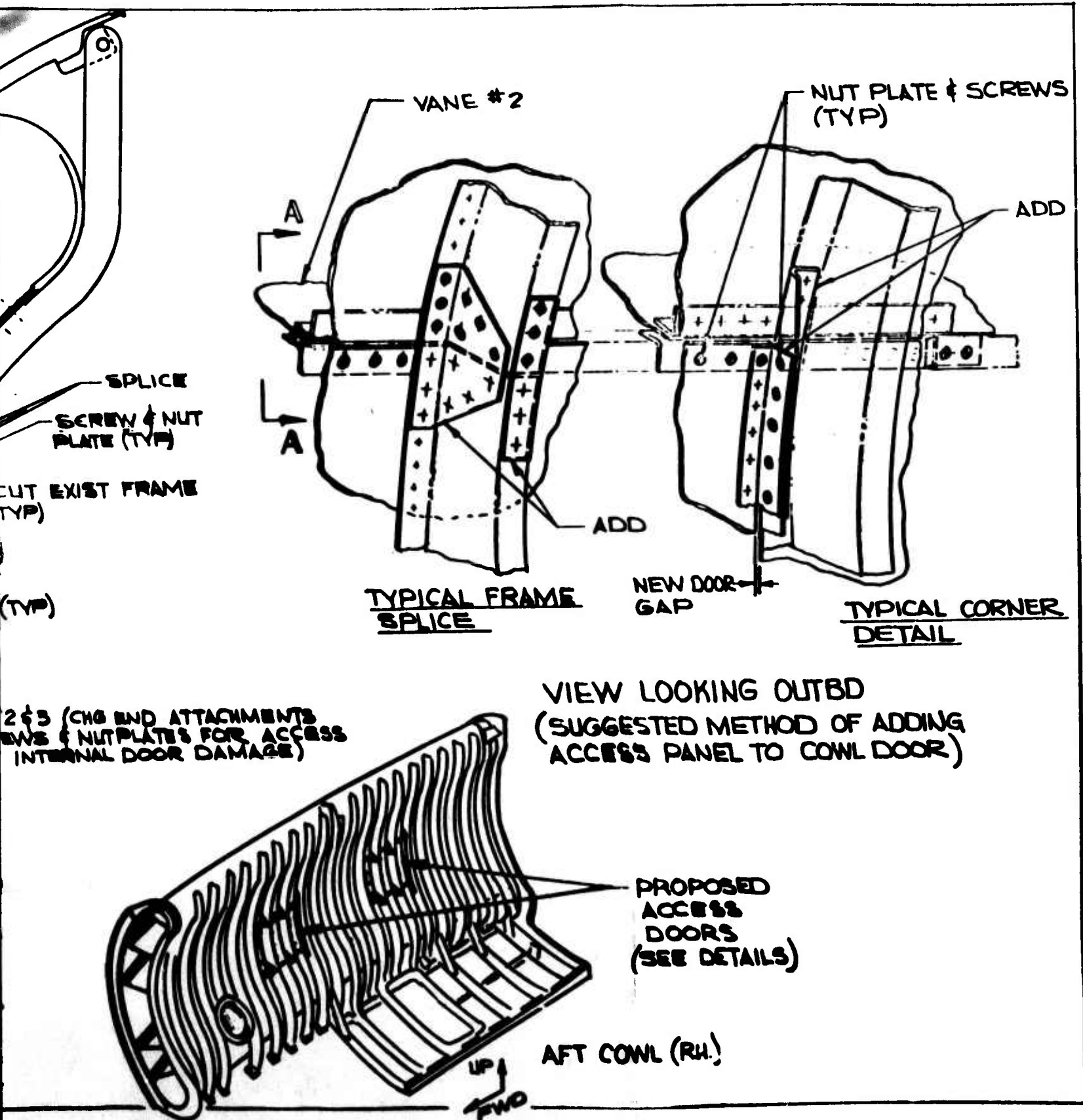


Figure 23. Item No. 14 - C-141 nacelle aft cowl door.

A mechanical attachment of the outboard vane attach member to supplement the integral bonding attachment as shown will also prevent disbonds in the honeycomb.

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#### PHASE IV - LIFE CYCLE COST ANALYSIS

For each selected critical item subjected to design study, the impact of improvements on life cycle costs for the specific aircraft systems were developed. Two specific time periods were used to evaluate the benefits of the redesign or repair concepts. The first was a 3-year period in which the design concept was required to "break even" (or pay for itself). The second was a 10-year operating period in which a reasonable return on the investment of change would be realized. In this program, the life cycle cost methodology was structured to use the basic methods contained in Air Force Regulation AFR 173-10, "Cost Analysis USAF Cost and Planning Factors," dated 6 February 1976.

The cost factors were separated into three basic categories:

- Research and Development Costs

The costs associated with the research and development of a military aircraft system are those required to design, fabricate, test, and evaluate the air vehicle system. For aircraft structures, this would include the costs for conducting research and evaluation testing of new materials, processes, and design concepts as part of a specific aircraft system program. Also included are the costs for fabrication of prototype aircraft structures and the validation tests conducted to ensure that the design requirements have been achieved.

- Acquisition Costs

Includes production (flyaway costs and initial spares) and other investment (initial training, AGE and training equipment, AGE and training spares, transportation, facilities, and recurring modifications).

- Operating Costs (Cost of Ownership)

Includes fuel and lubricants, direct base maintenance personnel (pay and allowances of personnel for inspection, maintenance up through base level, and repair up through base level), replenishment spares, depot maintenance, and base operations support and miscellaneous support (indirect operations costs such as pay and allowances of base operations support personnel, vehicular equipment, material support, rents, utilities, communications, printing and reproduction, medical services, and personnel training costs).

For the program, only the impact of the design innovations were required to determine the benefits of their implementation. Certain ground rules were

established to provide a uniform base of cost factors for both depot and operational units, as follows:

- Cost computations and parts bid estimates are based on 1975 dollar values.
- Some parts cost data from ALC show a different cost for left and right opposite parts. An average cost was used in computations.
- Oral estimates from responsible personnel at depots and operational bases for maintenance hours or costs was used where written documentary was unavailable.
- All present, maintenance costs which are not obtainable through contacts with AF facilities along with new parts and installation costs will be estimated by the contractor.
- All future cost estimates were based on current methods and capabilities.
- Quantities of aircraft in the inventory were based on the 1 March 1975 census furnished by AFFDL/FBS.
- Cost savings were based on a retrofit of the fleet within 1 year, on the PDM schedule, or within 3 years, as judged most logical for the particular design.
- If an item were to be implemented during PDM, only the delta costs peculiar to installation of the new design would be included in the cost saving analysis.
- The 10-year life cycle cost period was based on implementation of the new design by 1 October 1976.
- Implementation costs would include the engineering and T.C.T.O. preparation, part fabrication, packaging, installation, and initial kit-proofing where applicable.
- Life cycle cost formula and values provided in AFR 173-10 would be used where applicable.
- All miscellaneous life cycle cost items which are of minor significance and not otherwise identified would be estimated in a lump sum quantity.
- An overall maintenance man-hour rate of \$20.00 per hour was used for both depot and operational base modification costs.



- A 10-percent spares allocation would be used for each design concept and assumed to be procured at the same time as the modification parts.

Table 3 contains the summary of the inventory number of each aircraft type and the programmed depot maintenance (PDM) scheduled cycle for each.

For each design concept, two summary charts of costs were developed. The first contains detailed information on the costs for (1) the part or materials and the labor for the existing design and (2) the implementation of the low-cost design concept. The number of parts or quantity of material for a single aircraft is shown. The amortized cost of nonrecurring costs for the low-cost design concept include engineering, maintenance handbook revisions, preparation of the Time Compliance Technical Order (T.C.T.O.), testing and kit proofing, and packaging and shipment of the modification kit.

The second summary chart contains the comparison of life cycle cost impacts between the existing aircraft design and the low-cost design concept. It lists the nonrecurring and recurring cost factors for the existing and low-cost design concepts for 3- and 10-year periods. The nonrecurring costs consist of implementation of the aircraft fleet modification, parts or materials, and labor. The recurring costs include depot and base level maintenance labor, materials, spare parts, spares packaging and shipping, and base operational impacts. The total life cycle cost savings of the low-cost design concept over the existing present design is tabulated for both the 3- and 10-year periods.

The summary for the life cycle cost savings of each design concept study are contained in the tables as listed in the following:

<u>Aircraft Model</u>	<u>Design Concept</u>	<u>Table</u>
A-7D	Main landing gear trunnion pins and fittings	4 and 5
F-4 series	Fuselage fuel tank structure reinforcement	6 and 7
A/T-37 series	Engine tailpipe clamp	8 and 9
B-52D	Forward fuselage urinal area	10 and 11
B-52G/H	Forward fuselage urinal area	12 and 13
C-5A	Wing leading edge slat actuator door	14 and 15
C-5A	Engine cowl door hinge	16 and 17
C/KC-135	Wing rib joint	18 and 19

TABLE 3. AIRCRAFT UNITS AND PDM CYCLES

Aircraft Model	No. Units	PDM Schedule (mo)	Remarks
A-7D	390	42	
F-4C	295	30	3-year total units thru PDM = 1,535
F-4D	504	36	
RF-4C	379	48	
F-4E	603	48	
A-37	140	--	Special 16-month replacement of engine tailpipe clamps
T-37	763	--	
B-52D	127	36	
B-52G	174	48	Aircraft are on a 2-year corrosion control program
B-52H	95	48	
C-5A	77	None	AFM66-1 operational data and SAALC mod frequency
C-135	101	48	3-year total units thru PDM = 569.25
KC-135	658	48	

TABLE 4. COST BREAKDOWN - PRESENT AND LOW-COST DESIGNS  
Item No. 1 - Main Landing Gear Shock and Tension Strut Trunnion and Pin Assemblies  
Aircraft Model A-7D. Effect. on 390 Units. PIM Sched 42 Mo.

Present Design				Low-Cost Design			
Part or Matl	Qty	Cost	Total	Parts or Matl	Qty	Cost	Total
Pin	8	\$ 16.00	\$ 89.60 <sup>1</sup>	Pin	8	\$ 14.00	\$112.00 <sup>2</sup>
Trunnion, shock	2	314.50*	314.50 <sup>1</sup>	Trunnion, shock	2	23.50	23.50 <sup>3</sup>
Trunnion, tens.	2	196.00*	196.00 <sup>1</sup>	Trunnion, tens.	2	23.50	23.50 <sup>3</sup>
				Cover, trunnion (incl assy to trum)	4	6.57	26.28 <sup>2</sup>
Total			600.10	Total			185.28
Instl (labor at \$20/hr) <sup>4</sup>				Instl (labor at \$20/hr) <sup>4</sup>			
				Implementation (nonrecurring):		Total:	
				Engineering		4,484.00	
				Hndbk Rev		500.00	
				T.C.T.O. Prep		800.00	
				Pkg & Shipping		2,277.00	
				Test/kit Proofing		527.00	
				Total nonrec		\$8,588.00 <sup>5</sup>	
Aircraft total			\$600.10	Aircraft total			\$185.28 <sup>5</sup>
* Average							
1. Based on 70% pin and 50% trunnion replacement per Oklahoma City ALC.							
2. Based on 100% pin replacement with revised design and installation of all covers.							
3. Salvage cost on 50% of trunnions.							
4. Removal, installation, and checkout are part of PCM, and are same for both designs.							
5. Contractor estimate.							

TABLE 5. LIFE CYCLE COST COMPARISON

Item No. 1 - Main Landing Gear Shock and Tension Strut Trunnion and Pin Assemblies

Aircraft Model A-7D. Effect. on 390 Units.

Cost Description	334.28 Units 3-Yr Period		390 Units 10 Yr Period	
	Present	Low-Cost	Present	Low-Cost
Nonrecurring:				
Implementation		\$ 8,588		\$ 8,588
Fleet Modification				
Parts/Material		61,935		72,259
Labor at \$20/hr <sup>2</sup>		0		0
Recurring:				
Depot Maint Labor	0		0	
Base Maint Labor	0		0	
Material	0		0	
Spares	\$ 200,605	6,194	668,683	7,226
Spares Pkg & shipping <sup>1</sup>	1,718	195	5,727	228
Base Operations, other <sup>2</sup>				
Total	\$ 202,323	\$ 76,912	\$ 674,410	\$ 88,301
Savings:				
Present costs less low-cost		\$ 125,411		\$ 586,109
<p>1. Does not include unscheduled maintenance, which is assumed equal in both designs.</p> <p>2. All work assumed accomplished at ALC depot.</p>				

TABLE 6. COST BREAKDOWN - PRESENT AND LOW-COST DESIGNS

Item No. 4 - Fuselage Fuel Tank Walls and Floor Skins Reinforcement  
Aircraft Model F-4. Effect. on 1,781 Units. PIM Sched F-4C - 30 Mo, F-4D - 36 Mo,  
RF-4C & F-4E - 48 Mo

Present Design				Low-Cost Design			
Part or Matl	Qty	Cost	Total	Part or Matl	Qty	Cost	Total
Tanks 3, 4, 5 & 6 mod kit	1		\$ 2,521.87 <sup>1</sup>	Tank 3 reinf	1	\$ 147.84	\$ 147.84
				Tank 4 reinf	1	474.70	474.70
				Tank 5 reinf	1	371.90	371.90
				Tank 6 reinf	1	397.90	397.90
				Adhesive	21 lb	20.00/lb	420.00
Total			2,521.87	Total			1,812.34 <sup>2</sup>
Instl (labor at \$20/hr)	550 hr	\$20/hr	11,000.00	Instl (labor at \$20/hr)	84 hr <sup>3</sup>	\$20/hr	1,680.00
Implementation (nonrecurring):				Implementation (nonrecurring):		Total:	
				Engineering		70,856	
				Handbk Rev		1,400	
				T.C.T.O. Prep		800	
				Pkg & Shipping		130,733	
				Test/Kit Proofing		2,450	
				Total nonrec		206,239 <sup>3</sup>	
Aircraft total			\$13,521.87	Aircraft total			\$3,492.34

1. Ref Telecon D.O. Jones, MEMS, OOALC, Hill AFB, Utah, dated 2 July 1975.

2. Ref quotes Russell Ind, Long Island, N.Y. per telecon, dated 17 June 1975.

3. Contractor estimate.

4. Ref Telecon Robt. Jensen, Tech. Services, OOALC, Hill AFB, Utah, dated 24 July 1975.

TABLE 7. LIFE CYCLE COST COMPARISON

Item No. 4 - Fuselage Fuel Tank Walls and Floor Skins Reinforcement

Aircraft Model F-4. Effect. on 1,781 Units.

Cost Description	1,535 Units 3 Yr Period		1,781 Units 10 Yr Period	
	Present	Low-Cost	Present	Low-Cost
Nonrecurring:				
Implementation		\$ 206,239		\$ 206,239
Fleet Modification				
Parts/Material	\$ 3,871,070	2,781,942	\$ 4,491,450	3,227,777
Labor at \$20/hr	16,885,000	2,578,800	19,591,000	2,992,080
Recurring:				
Depot Maint Labor				
Base Maint Labor				
Material				
Spares				
Spares Pkg & shipping				
Base Operations, other				
Total	\$20,756,070	\$ 5,566,981	\$24,082,450	\$ 6,426,096
Savings:				
Present costs less low-cost		\$15,189,089		\$17,656,354



TABLE 8. COST BREAKDOWN - PRESENT AND LOW-COST DESIGNS

Item No. 5 - Engine Tailpipe Clamp

Aircraft Model A/T-37. Effect. on 903 Units. PDM Sched Spec. Repl. at 16 Mo.

Present Design				Low-Cost Design			
Part or Matl	Qty	Cost	Total	Part or Matl	Qty	Cost	Total
Clamp assy	2	\$25.20 <sup>2</sup>	\$ 50.40	Spring Bolt & nut Washer	4 4 8	\$ 0.75 4.84 0.14	\$ 3.00 19.36 1.12
Total			50.40	Total			23.48
Instl (labor at \$20/hr)	2 hr <sup>3</sup>	\$20/hr	40.00	Instl (labor at \$20/hr)	2 hr <sup>1</sup>	\$20/hr	40.00
				Implementation (nonrecurring): Engineering Hndbk Rev T.C.T.O. Prep Pkg & Shipping Test/kit Proofing		Total: \$ 3,488 300 1,000 13,527 550	
				Total Nonrec		\$18,865 <sup>1</sup>	
Aircraft total			90.40	Aircraft total			\$ 63.48

1. Contractor estimate.
2. Ref WPAFB ADOPL Product No. D046.E61A, dated 12 May 1975.
3. Ref T.C.T.O. 1T-37 B-506.

TABLE 9. LIFE CYCLE COST COMPARISON

Item No. 5 - Engine Tailpipe Clamp

Aircraft Model A/T-37. Effect. on 903 Units.

Cost Description	3 Yr Period		10 Yr Period	
	Present	Low-Cost	Present	Low-Cost
Nonrecurring <sup>1</sup> :				
Implementation		\$ 18,865		\$ 18,865
Fleet Modification				
Parts/Material		21,202		21,202
Labor at \$20/hr		36,120		36,120
Recurring:				
Depot Maint Labor				
Base Maint Labor	\$ 81,270		270,900	3,612 <sup>2</sup>
Material				
Spares	102,400	2,120	341,334	2,120
Spares Pkg & shipping		1,353		1,353
Base Operations, other <sup>3</sup>				
<b>Total</b>	<b>\$ 220,891</b>	<b>\$ 96,203</b>	<b>\$ 736,306</b>	<b>\$ 101,469</b>
Savings:				
Present costs less low-cost		\$ 124,688		\$ 634,837
1. Assumes low-cost design installed within 3 years. 2. Spares installation. 3. Included in basic \$20.00-per-hour labor rate.				

TABLE 10. COST BREAKDOWN - PRESENT AND LOW-COST DESIGNS

Item No. 8A - Forward Fuselage Urinal Area, Section 41  
Aircraft Model B-52D. Effect. on 127 Units. PDM Sched 36 Mo.

Present Design				Low-Cost Design			
Part or Matl	Qty	Cost	Total	Part or Matl	Qty	Cost	Total
Misc corrosion control parts & material			\$ 150.00 <sup>1</sup>	Pan Panel	1 1	\$ 65.00 65.00	\$ 65.00 65.00
Total			150.00	Total			130.00 <sup>3</sup>
Instl (labor at \$20/hr)	546 hr <sup>2</sup>	\$20/hr	10,920.00	Instl (labor at \$20/hr)	4 hr <sup>3</sup>	\$20/hr	80.00
				Implementation (nonrecurring): Engineering Hndbk Rev T.C.T.O. Prep Pkg & Shipping Test/kit Proofing		Total: 14,797 500 1,200 6,590 520	
				Total nonrec		\$ 23,607 <sup>3</sup>	
Aircraft total			\$11,070.00	Aircraft total			\$ 210.00

1. Cost estimate by contractor based on observation at Oklahoma City ALC.
2. Ref estimate by Oklahoma City ALC for corrosion program on PDM for FY 1976.
3. Contractor estimate.

TABLE 11. LIFE CYCLE COST COMPARISON

Item No. 8A - Forward Fuselage Urinal Area, Section 41

Aircraft Model B-52D. Effect. on 127 Units.

Cost Description	3 Yr Period		10 Yr Period	
	Present	Low-Cost	Present	Low-Cost
Nonrecurring:				
Implementation		\$ 23,607		\$ 23,607
Fleet Modification				
Parts/Material		16,510		16,510
Labor at \$20/hr		10,160		10,160
Recurring:				
Depot Maint Labor	\$ 1,386,840	0	\$ 4,622,800	808,990 <sup>1</sup>
Base Maint Labor	0	0	0	0
Material	19,050	0	63,500	11,375 <sup>1</sup>
Spares	0	0	0	0
Spares Pkg & shipping	0	0	0	0
Base Operations, other				
Total	\$ 1,405,890	\$ 50,277	\$ 4,686,300	\$ 870,642
Savings:				
Present costs less low-cost		\$ 1,355,613		\$ 3,815,658
1. Based on low-cost design, reducing corrosion control effort and material requirement by 75%.				

TABLE 12. COST BREAKDOWN - PRESENT AND LOW-COST DESIGNS

Item No. 8B - Forward Fuselage Urinal Area, Section 41  
Aircraft Model B-52 G & H. Effect. on 272 Units. PDM Sched 48 Mo.

Present Design				Low-Cost Design			
Part or Matl	Qty	Cost	Total	Part or Matl	Qty	Cost	Total
Misc corrosion control parts & material			\$ 150.00 <sup>1</sup>	Shield	1	\$ 195.00	\$ 195.00
Total			150.00	Total			195.00
Instl (labor at \$20/hr)	546 hr <sup>2</sup>	\$20/hr	10,920.00	Instl (labor at \$20/hr)	5 hr <sup>3</sup>	\$20/hr	100.00
				Implementation (nonrecurring):		Total:	
				Engineering		22,195	
				Indbk Rev		500	
				T.C.T.O. Prep		1,200	
				Pkg & Shipping		21,166	
				Test/kit Proofing		520	
				Total nonrec		\$45,581 <sup>3</sup>	
Aircraft total			\$11,070.00	Aircraft total			\$ 295.00

1. Cost estimate by contractor based on observation at Oklahoma City ALC.
2. Ref estimate by Oklahoma City ALC for corrosion on 2-year fly-in program.
3. Contractor estimate.

TABLE 15. LIFE CYCLE COST COMPARISON

Item No. 8B - Forward Fuselage Urinal Area, Section 41

Aircraft Model B-52 G &amp; H. Effect. on 272 Units.

Cost Description	408 Units 3 Yr Period		10 Yr Period	
	Present	Low-Cost	Present	Low-Cost
Nonrecurring:				
Implementation		\$ 45,581		\$ 45,581
Fleet Modification				
Parts/Material		53,040		53,040
Labor at \$20/hr		27,200		27,200
Recurring:				
Depot Maint Labor	\$ 4,455,360	371,280	\$14,851,200	2,970,240 <sup>1</sup>
Base Maint Labor				
Material	61,200	5,100	204,000	40,800 <sup>1</sup>
Spares	0	0	0	0
Spares Pkg & shipping	0	0	0	0
Base Operations, other				
<b>Total</b>	<b>\$ 4,516,560</b>	<b>\$ 502,201</b>	<b>\$15,055,200</b>	<b>\$ 3,136,861</b>
Savings:				
Present costs less low-cost		\$ 4,014,359		\$11,918,339
1. Based on low-cost design, reducing corrosion control effort and material requirement by 75%.				



TABLE 14. COST BREAKDOWN - PRESENT AND LOW-COST DESIGNS

Item No. 9 - Wing Leading Edge Slat Actuator Door

Aircraft Model C-5A. Effect. on 77 Units. PDM Sched None.

Present Design				Low-Cost Design			
Part or Matl	Qty	Cost	Total	Part or Matl	Qty	Cost	Total
Rwd ball fitting	56	\$13.00 <sup>1</sup>	\$ 37.70 <sup>2</sup>	-1 Guide, aft	56	\$ 4.88	\$ 273.28
Attachment fitting	56	36.75 <sup>1</sup>	106.57 <sup>2</sup>	-2 Guide, fwd	20	13.67	273.40
Total			144.28	Total			546.68
Instl (labor at \$20/hr)	17.6 hr <sup>3</sup>	\$20/hr	352.00	Instl (labor at \$20/hr)	31 hr <sup>1</sup>	\$20/hr	620.00
				Implementation (nonrecurring):		Total:	
				Engineering		8,968.00	
				lndbk Rev		2,000.00	
				T.C.T.O. Prep		1,400.00	
				Pkg & Shipping		2,961.00	
				Test/kit Proofing		1,135.00	
				Total nonrec		\$16,464.00	
Aircraft total			\$496.28	Aircraft total			\$1,166.68

1. Contractor estimate

2. Based on 4.83 maintenance actions per aircraft per year and replacement of 2.90 parts per year.

3. Man-hours obtained from AFM 66-1.

TABLE 15. LIFE CYCLE COST COMPARISON

Item No. 9 - Wing Leading Edge Slat Actuator Door

Aircraft Model C-5A. Effect. on 77 Units.

Cost Description	3 Yr Period		10 Yr Period	
	Present	Low-Cost	Present	Low-Cost
Nonrecurring:				
Implementation		\$ 16,464		\$ 16,464
Fleet Modification				
Parts/Material		42,094		42,094
Labor at \$20/hr		47,740		47,740
Recurring:				
Depot Maint Labor	0	0	0	0
Base Maint Labor	\$ 81,312	0	271,040	4,680
Material	0	0	0	0
Spares	33,711	4,209	111,096	4,209
Spares Pkg & shipping	569	57	1,897	57
Base Operations other <sup>1</sup>				
<b>Total</b>	<b>\$ 115,210</b>	<b>\$ 110,564</b>	<b>\$ 140,133</b>	<b>\$ 110,564</b>
Savings:				
Present costs less low-cost		\$ 4,646		\$ 29,569
1. Costs included in basic \$20.00-per-hour labor rate.				

TABLE 16. COST BREAKDOWN - PRESENT AND LOW-COST DESIGNS

Item No. 10 - Engine Cowl Door Hinge

Aircraft Model C-5A. Effect. on 77 Units. PDM Sched None.

Present Design				Low-Cost Design			
Part or Matl	Qty	Cost	Total	Part or Matl	Qty	Cost	Total
Hinge	8	\$69.12 (avg)	\$ 552.96	Hinge	8	\$ 31.00	\$ 248.00
Total			552.96	Total			248.00
Instl (labor at \$20/hr)	16 hr <sup>1</sup>	\$20/hr	320.00	Instl (labor at \$20/hr)	16 hr <sup>2</sup>	\$20/hr	320.00
				Implementation (nonrecurring): Engineering Hndbk Rev T.C.T.O. Prep Pkg & Shipping Test/kit Proofing		Total: 2,241.00 300.00 800.00 412.00 1,135.00	
				Total nonrec		\$4,888.00 <sup>2</sup>	
Aircraft total			\$ 872.96	Aircraft total			\$ 568.00

1. Man-hours provided verbally by engine cowl shop personnel at SAALC.

2. Contractor estimate.

TABLE 17. LIFE CYCLE COST COMPARISON

Item No. 10 - Engine Cowl Door Hinge

Aircraft Model C-5A. Effect. on 77 Units

Cost Description	3 Yr Period		10 Yr Period	
	Present	Low-Cost	Present	Low-Cost
Nonrecurring:				
Implementation		\$ 4,888		\$ 4,888
Fleet Modification				
Parts/Material		19,096		19,096
Labor at \$20/hr		24,640		24,640
Recurring:				
Depot Maint Labor	\$ 24,640	0	82,133	2,480
Base Maint Labor	0	0	0	0
Material	0	0	0	0
Spares	42,578	1,922	141,946	1,922
Spares Pkg & shipping	385	39	1,283	39
Base Operations, other <sup>1</sup>				
Total	\$ 67,603	\$ 50,585	\$ 225,362	\$ 53,065
Savings:				
Present costs less low-cost		\$ 17,018		\$ 172,297
1. All work accomplished at ALC depot.				

TABLE 18. COST BREAKDOWN - PRESENT AND LOW-COST DESIGNS

Item No. 13 - Inner-to-Outer-Wing Joint Rib  
Aircraft Model C/KC-135. Effect. on 759 Units. PIM Sched 48 Mo.

Present Design				Low-Cost Design			
Part or Matl	Qty	Cost	Total	Part or Matl	Qty	Cost	Total
Rib, inner	2	\$4,233.00	\$8,466.00 <sup>1</sup>	Mylar cover	2	\$ 0.20	\$ 0.40
Rib, outer	2	3,827.00	7,654.00 <sup>1</sup>	Adhesive	1 pint	1.60	1.60
Total			16,120.00 <sup>1</sup>	Total			2.00
Instl (labor at \$20/hr)	2,400 hr <sup>1,3</sup> 36 hr <sup>2</sup>		48,000.00 720.00	Instl (labor at \$20/hr)	3 hr <sup>4</sup>	\$20/hr	60.00
				Implementation (nonrecurring):		Total:	
				Engineering		2,241.00	
				Indbk Rev		400.00	
				T.C.T.O. Prep		1,000.00	
				Pkg & Shipping		7,348.00	
				Test/kit Proofing		520.00	
				Total nonrec		\$11,509.00 <sup>4</sup>	
Aircraft total			\$64,120.00 <sup>1</sup> 720.00 <sup>2</sup>	Aircraft total		\$ 62.00	

1. Only for aircraft that require rib replacement. Estimated at three aircraft per year by OCALC.
2. For corrosion control on aircraft that do not require rib replacement. Estimate by contractor.
3. Man-hours provided by OCALC.
4. Contractor estimate.

TABLE 19. LIFE CYCLE COST COMPARISON

Item No. 13 - Inner-to-Outer-Wing Joint Rib

Aircraft Model C/KC-135. Effect. on 759 Units.

Cost Description	569.25 Units 3 Yr Period		10 Yr Period	
	Present	Low-Cost	Present	Low-Cost
Nonrecurring:				
Implementation		\$ 11,509		\$ 11,509
Fleet Modification				
Parts/Material <sup>3</sup>		1,518		1,518
Labor at \$20/hr <sup>3</sup>		45,540		45,540
Recurring:				
Depot Maint Labor	\$ 835,380 <sup>2</sup>		\$ 2,784,600 <sup>2</sup>	\$ 136,620 <sup>4</sup>
Base Maint Labor				
Material				
Spares	145,080 <sup>1</sup>	152	483,600 <sup>1</sup>	152
Spares Pkg & shipping	4,980 <sup>1</sup>		16,600 <sup>1</sup>	
Base Operations other <sup>5</sup>				
Total	\$ 985,440	\$ 58,719	\$ 3,284,800	\$ 195,339
Savings:				
Present costs less low-cost		\$ 926,721		\$ 3,089,461
1. Based on three aircraft per year requiring rib replacement per OCALC. 2. Includes rib replacement at three aircraft per year and corrosion control on remainder. 3. Based on all 759 aircraft having change accomplished in 1 year. 4. Assumes a residual of 10% of original corrosion costs incurred. 5. Costs included in basic \$20.00-per-hour labor costs.				



TABLE 20. ESTIMATED COST SAVINGS SUMMARY

Item No.	Title	3 Yr Saving	10 Yr Saving
1	A-7D MLG Strut Trunnion and Pin Assy - 390 Units	\$ 125,411	\$ 586,109
4	F-4 Fuselage Fuel Tank Skins Reinforcement - 1781 Units	15,189,089	17,656,354
5	A/T-37 Engine Tailpipe Clamp - 903 Units	124,688	634,837
8A	B-52D Forward Fus Urinal Area Section 41 - 127 Units	1,355,613	3,815,658
8B	B-52 G, H Forward Fus Urinal Area Section 41 - 272 Units	4,014,359	11,918,339
9	C5A Wing LE Slat Actuator Doors - 77 Units	4,646	29,569
10	C-5A Engine Cowl Door Hinge - 77 Units	17,018	172,297
13	C/KC - 135 Inner to Outer Wing Joint Rib - 759 Units	926,721	3,089,461
Totals		\$21,757,545	\$37,902,624

The total summary of estimated cost savings for the critical items studied is contained in Table 20, which indicates that substantial reductions in military aircraft maintenance costs can be achieved for relatively modest expenditures of material and labor at both the operational base and ALC depot level activities.

#### PHASE V - PREPARE DESIGN HANDBOOK

The objective of phase V was to develop a design guide handbook to serve a growing need in the military in order to obtain lower aircraft structural maintenance costs to a more reasonable level commensurate with acceptable life cycle costs. It was designed as an informative guide which will aid the aircraft designer in foreseeing maintenance problems and making proper trade-off evaluations to optimize the structural design for total life cycle costs.

The handbook points up several examples of high-maintenance-cost items on existing inservice aircraft and suggests changes to substantially reduce the life cycle cost. In addition, many other costly maintenance items discovered during visits to military and industry maintenance and repair facilities are cited which could have been avoided or substantially reduced by more cost-effective considerations for serviceability during design.

In this respect, the handbook includes not only information on past problem areas in the form of "lessons learned," but recommended considerations during initial design of every aspect of structural development. Since corrosion-damage repair was found to be one of the most costly maintenance items, a part of the handbook provides design information usable in its prevention. Also, since the handbook is directed primarily toward the development of military aircraft, a section is devoted to battle damage and design considerations to increase survivability and permit repairs to minimize downtime on the aircraft.

The design handbook is divided in eight sections as follows:

- Section 1 - Introduction
- Section 2 - Use of Handbook
- Section 3 - Background
- Section 4 - Lessons Learned
- Section 5 - General Design Considerations
- Section 6 - Detail Design Considerations
- Section 7 - Repair or Modification Design
- Section 8 - References

The following paragraphs contain a brief description of the type of information contained in each section.

Section 1 introduces the designer to the handbook with a brief review of the reasons for the development of the handbook, how the information was collected, and the importance of considering maintenance and repair costs during initial design of an aircraft.

Section 2 recommends to the designer the use of the handbook and provides a brief insight of the information contained in each section.

Section 3 acquaints the designer on how the information for the handbook was obtained, the types of aircraft that were considered for inclusion in the handbook, and some of the major factors to be considered during the design of an aircraft to reduce maintenance costs.

Section 4 points out that many design deficiencies that are appearing on current aircraft structures have occurred on previous generations of aircraft. In this section, a number of repetitive problems are identified so that designers of future aircraft structures may take advantage of the lessons learned. The design deficiency problems encountered at the repair facilities have been grouped in five main categories: lubrication deficiencies, corrosion-protection deficiencies, material selection deficiencies, detail design deficiencies, and fatigue design deficiencies. In each category there are examples of the deficiency with a photograph or a sketch, a statement of the problem, and the cause.

Section 5 contains general design consideration information on design techniques for low-cost structural maintenance features that may be incorporated into new aircraft systems. These design techniques are material selection, structural assembly arrangements, aircraft subsystem interfaces, removable and hinged doors, radomes and engine cowls, crew/passenger/cargo provisions, sealing and organic bonding, corrosion prevention, fasteners, and special design considerations.

Section 6 is one of the most important sections for the designer of new aircraft. It contains detail information on construction concepts, material selection, corrosion control, maintenance, life cycle cost impact considerations, trade factors, and a design checklist. There is a table for structural fasteners that provides the part name, type, material and strength, weight, cost, cost installed, maximum misalignment, maximum temperature, and remarks. A materials recommendation for primary structure table provides information on the type of materials, environment, candidate materials, typical application, advantages, and limitations. A cost breakdown table shows an example of the maintenance and parts cost of a present design on one aircraft and the potential savings on that one

aircraft in 1 year thru an innovative repair design. A life cycle cost comparison table shows the potential savings of this repair design for the entire fleet of this aircraft over 3- and 10-year periods.

Section 7 contains information on repair or modifications, designs and their drawings and kits. The section also contains battle-damaged repairs with a number of examples of typical battle-damaged repair concepts. Also included are repair concepts with design drawings for some of the design deficiencies listed in Section 4.

Section 8 is a listing of data sources used for the development of the design handbook.

## SECTION VI

### CONCLUSIONS AND RECOMMENDATIONS

#### CONCLUSIONS

In the performance of this program, specific conclusions were developed from the analysis of the information and data obtained and from the personal contacts with military and industry personnel engaged in aircraft structural repair and maintenance. They address a number of areas covered in the investigation and are presented as a part of an effort to provide the reader with an appreciation of the benefits of the study results, and to identify specific areas of aircraft structure maintenance reporting systems that could be modified to provide more useful information to the aircraft system managers, Air Logistics Centers, Air Force Logistics Command Headquarters, Air Force Flight Dynamics Laboratory, Air Force Materials Laboratory, the using commands, and the aircraft manufacturers.

1. The results of the design innovation studies and the life cycle cost analyses have conclusively shown that considerable savings in the cost-of-ownership related to maintenance and repair of aircraft structures can be realized. In many instances, such benefits can be gained for relatively small initial expenditures that would provide the Air Force with a significant return on its investment. The vast amounts of expenditures currently needed to support existing aircraft operations is considered to be a fertile area for numerous improvements and savings that can be achieved on all categories of military aircraft.
2. The capability to obtain sufficient valid data on the cost of military aircraft structure maintenance and repair, for analysis and identification of specific problem areas, is severely hampered by the existing cost accounting systems in the Air Logistics Centers and the limitations in the AFM66-1 reporting system. Neither of these systems were originally developed to provide such detail data, and unless some requirement is endorsed to modify the existing methods, the only way that specific information can be obtained is through onsite visitations and discussions with the maintenance personnel directly associated with a given aircraft system.
3. The existing coverage and description of aircraft structures in the AFM66-1 system is not detailed enough to permit identification of specific problems. This is due to the lack of any criteria for the assignment of work unit codes (WUC) for structural elements at time



of design and manufacture. The "how malfunction codes" (HMC) and "action taken codes" (ATC) are not sufficiently defined and/or described to ensure that the data reported can be analyzed to produce adequate identification of problem causes, occurrences, and corrective actions required. For example, how malfunction code 070 designates "broken," and HMC 111 designates "burst" or "broken." The existing instructions in the WUC manuals used by maintenance personnel do not provide adequate explanation on their applications. Similarly, ATC "F" designates "repair," and ATC "G" designates "repair or replace." ATC "P" designates "remove," and ATC "R" designates "remove and replace." These codes were initially developed for use on line replaceable units (LRU's) where subsystem technicians have been fully trained in the utilization of the HMC and ATC items that apply to replaceable equipment. Unfortunately, no clear-cut ground rules are available for structure repair and replacement.

#### RECOMMENDATIONS

From the results of the study, and the conclusions drawn, certain recommendations have been developed. They are presented for two basic areas. The first of these are those recommendations for cost savings on existing aircraft systems. The second set of recommendations are for improvements in the reporting of aircraft structure maintenance and repair efforts on existing and future aircraft that will permit adequate analysis of aircraft structure conditions and problems so that profitable improvements may be initiated in a systematic and timely fashion.

1. Based upon the results of the design and life cycle cost research and analysis conducted on the selected critical items in this program, it is recommended that their implementation be considered by the specific aircraft system managers. Information and briefings to these activities have been provided by AFFDL/FBS for their information and review.
2. A number of other candidate structure improvement potentials have been identified in this program. It is recommended that consideration be given to additional design improvement studies to provide the Air Force with additional opportunities for life cycle cost savings on existing aircraft systems.
3. The AFM66-1 maintenance reporting system has not been effectively applied to aircraft structure use. Significant system management insights and cost savings could be realized if adequate information



could be provided to these offices. It is recommended that a study be conducted to analyze the improvements that can be developed in the use of the AFM66-1 system for existing and future aircraft structure maintenance and repair monitoring. Elements that should be included in this study are:

- Criteria established for assignment of work unit code (WUC) identification of structure elements in future aircraft.
- Criteria and guidance for use and/or improvement of how malfunction codes and action taken codes.
- Criteria for establishment of WUC to aircraft part number cross indexes to facilitate and improve AFM66-1 reporting accuracy. Such indexes are currently employed by the U.S. Navy in their 3M maintenance reporting system.
- Conduct an analysis for the use of AFM66-1 reporting system in certain repair categories by the Air Logistics Centers so that significant repair information would be available for analysis and review by the aircraft system managers. This approach is being used by the U.S. Navy with the 3M system.

APPENDIX

CANDIDATE CRITICAL ITEMS

SUMMARY SHEETS

947 TORN

U - NON-DESTRUCT INSP

**X - TEST, INSPECT-SERVICE**

96



020 WORN, CHAFED, OR FRAYED  
070 BROKEN  
105 LOOSE OR DAMAGED BOLTS  
106 MISSING BOLTS, SCREWS,  
111 BURST OR BROKEN  
116 CUT  
117 DETERIORATED  
135 BENDING, STUCK, OR JAMMED  
170 CORRODED  
190 CRACKED  
425 NICKED  
520 PITTED  
540 PUNCTURED  
585 SHEARED  
605 CRAZED  
660 STRIPPED  
731 BATTLE DAMAGE  
780 BENT, BUCKLED, COLLAPSED  
846 DELAMINATED  
878 WEATHER DAMAGE  
910 CHIPPED  
917 IMPENDING FAILURE  
935 SCORED OR SCRATCHED  
947 TORN

WHEN DISCOVERED CODES

A - BEFORE FLIGHT - ABORT  
B - BEFORE FLIGHT - NO ABORT  
C - IN-FLIGHT - ABORT  
D - IN-FLIGHT - NO ABORT  
E - AFTER FLIGHT - AIR CREW  
F - BETWEEN FLIGHTS - GROUND  
G - GROUND ALERT - NOT DEGRADED  
H - BASIC POST FLIGHT  
J - PREFLIGHT INSP  
K - POST FLIGHT INSP  
M - PERIODIC/PHASED INSP  
N - GROUND ALERT - DEGRADED  
P - FUNCTIONAL CHECKFLIGHT  
Q - SPECIAL INSP  
R - QUALITY CONTROL CHECK  
S - DEPOT LEVEL MAINTENANCE  
U - NON-DESTRUCT INSP

**ACTION TAKEN CODES**

F - REPAIR  
G - REPAIR OR REPLACE  
L - ADJUST  
P - REMOVE  
Q - INSTALL  
R - REMOVE AND REPLACE  
X - TEST, INSPECT-SERVICE

[illegible]



020 WORN, CHAFED, OR FRAYED  
070 BROKEN  
105 LOOSE OR DAMAGED BOLTS  
106 MISSING BOLTS, SCREWS,  
111 BURST OR BROKEN  
116 CUT  
117 DETERIORATED  
135 BENDING, STUCK, OR JAMMED  
170 CORRODED  
190 CRACKED  
425 NICKED  
520 PITTED  
540 PUNCTURED  
585 SHEARED  
605 CRAZED  
660 STRIPPED  
731 BATTLE DAMAGE  
780 BENT, BUCKLED, COLLAPSED  
846 DELAMINATED  
878 WEATHER DAMAGE  
910 CHIPPED  
917 IMPENDING FAILURE  
935 SCORED OR SCRATCHED  
947 TORN

WHEN DISCOVERED CODES

A - BEFORE FLIGHT - ABORT  
B - BEFORE FLIGHT - NO ABORT  
C - IN-FLIGHT - ABORT  
D - IN-FLIGHT - NO ABORT  
E - AFTER FLIGHT - AIR CREW  
F - BETWEEN FLIGHTS - GROUND  
G - GROUND ALERT - NOT DEGRADED  
H - BASIC POST FLIGHT  
J - PREFLIGHT INSP  
K - POST FLIGHT INSP  
M - PERIODIC/PHASED INSP  
N - GROUND ALERT - DEGRADED  
P - FUNCTIONAL CHECKFLIGHT  
Q - SPECIAL INSP  
R - QUALITY CONTROL CHECK  
S - DEPOT LEVEL MAINTENANCE  
U - NON-DESTRUCT INSP

**ACTION TAKEN CODES**

F - REPAIR  
G - REPAIR OR REPLACE  
L - ADJUST  
P - REMOVE  
Q - INSTALL  
R - REMOVE AND REPLACE  
X - TEST, INSPECT-SERVICE

AIRCRAFT MODEL B-52-H	
MUC - 11EMA	
TITLE: BOMB BAY	
DOOR ASSY.	
TYPE STRUCTURE	OVERALL STRUCTURE
STRUCT. IMPORTANCE	AIRFRAME
PART FORM	LOG GEAR
PART MATERIAL	FL. CONT.
MUC-MMH/FH RANK	OTHER
VALUE MMH/1000FH	PRIMARY
MOR RANKING	SECONDARY
MMH RANKING	OTHER
1ROS COST RANKINGS	FORGING
	CASTING
	SHEET
	PLATE
	ROO
	BOLTS & FAST
	EXTR:
	H. COMB
	ASSY
	OTHER
	ALUM.
	STEEL
	TITAN
	FIBERGLAS
	MAGNESIUM
	COMBINATION
	TRANSPARENT
HOW MAL. CODES	
HMC-MOR RANK	
HMC-MMH RANK	
HIGHEST MH DISC. CODE	
HIGHEST ACT. TAKEN CODE	
	SUMMARY



947 TORN

U - NON-DESTRUCT INSP

X - TEST, INSPECT-SERVICE

100

020 WORN, CHAFED, OR FRAYED  
070 BROKEN  
105 LOOSE OR DAMAGED BOLTS  
106 MISSING BOLTS, SCREWS,  
111 BURST OR BROKEN  
116 CUT  
117 DETERIORATED  
135 BENDING, STUCK, OR JAMMED  
170 CORRODED  
190 CRACKED  
425 NICKED  
520 PITTED  
540 PUNCTURED  
585 SHEARED  
605 CRAZED  
660 STRIPPED  
731 BATTLE DAMAGE  
780 BENT, BUCKLED, COLLAPSED  
846 DELAMINATED  
878 WEATHER DAMAGE  
910 CHIPPEO  
917 IMPENDING FAILURE  
935 SCORED OR SCRATCHED  
947 TORN

WHEN DISCOVERED COOES

WHEN DISCOVERED CODES

- A - BEFORE FLIGHT - ABORT
- B - BEFORE FLIGHT - NO ABORT
- C - IN-FLIGHT - ABORT
- D - IN-FLIGHT - NO ABORT
- E - AFTER FLIGHT - AIR CREW
- F - BETWEEN FLIGHTS - GROUND
- G - GROUND ALERT - NOT DEGRADED
- H - BASIC POST FLIGHT
- J - PREFLIGHT INSP
- K - POST FLIGHT INSP
- M - PERIODIC/PHASED INSP
- N - GROUND ALERT - DEGRADED
- P - FUNCTIONAL CHECKFLIGHT
- Q - SPECIAL INSP
- R - QUALITY CONTROL CHECK
- S - DEPOT LEVEL MAINTENANCE
- U - NON-DESTRUCT INSP

**ACTION TAKEN CODES**

F - REPAIR  
G - REPAIR OR REPLACE  
L - ADJUST  
P - REMOVE  
Q - INSTALL  
R - REMOVE AND REPLACE  
X - TEST, INSPECT-SERVICE

AIRCRAFT MODEL	B-52
MUC -	
TITLE:	ORIGINAL AREA
STRUCTURE	
TYPE STRUCTURE	
STRUCT. IMPORTANCE	
PART FORM	
PART MATERIAL	
MUC-MMH/FH RANK	
VALUE MMH/1000FH	
HDR RANKING	
MMH RANKING	
IROS COST RANKINGS	
HOW MAL. CODES	
HMC-HDR RANK	
HMC-MMH RANK	
HIGHEST WM DISC. CODE	
HIGHEST ACT. TAKEN CODE	
	OVERALL STRUCTURE
	X AIRFRAME
	LOG GEAR
	FL. CONT.
	OTHER
	X PRIMARY
	SECONDARY
	OTHER
	FORGING
	CASTING
	SHEET
	PLATE
	ROD
	BOLTS & FAST
	EXTR:
	H. COMB
	X ASSY
	OTHER
	X ALUM.
	STEEL
	TITAN
	FIBERGLAS
	MAGNESIUM
	COMBINATION
	TRANSPARENT
	(NOT IN AFM66-1 DATA)
020	
070	
105	
106	
111	
116	
117	
135	
170	
190	
425	
520	
540	
585	
605	
660	
731	
780	
846	
878	
910	
917	
935	
947	
SUMMARY	

WHEN DISCOVERED CODES

- A - BEFORE FLIGHT - ABORT
- B - BEFORE FLIGHT - NO ABORT
- C - IN-FLIGHT - ABORT
- O - IN-FLIGHT - NO ABORT
- E - AFTER FLIGHT - AIR CREW
- F - BETWEEN FLIGHTS - GROUND
- G - GROUND ALERT - NOT DEGRADED
- H - BASIC POST FLIGHT
- J - PREFLIGHT INSP
- K - POST FLIGHT INSP
- M - PERIODIC/PHASED INSP
- N - GROUND ALERT - DEGRADED
- P - FUNCTIONAL CHECKFLIGHT
- Q - SPECIAL INSP
- R - QUALITY CONTROL CHECK
- S - DEPOT LEVEL MAINTENANCE
- U - NON-DESTRUCT INSP

**ACTION TAKEN CODES**  
**F - REPAIR**  
**G - REPAIR OR REPLACE**  
**L - ADJUST**  
**P - REMOVE**  
**Q - INSTALL**  
**R - REMOVE AND REPLACE**  
**X - TEST, INSPECT-SERVICE**

102

**ACTION TAKEN CODES**  
**F - REPAIR**  
**G - REPAIR OR REPLACE**  
**L - ADJUST**  
**P - REMOVE**  
**Q - INSTALL**  
**R - REMOVE AND REPLACE**  
**X - TEST, INSPECT-SERVICE**

103



947 TDRN

**U - NON-DESTRUCT INSP**

**X - TEST, INSPECT-SERVICE**

104

## CODE NOMENCLATURE

020 WORN, CHAFED, OR FRAYED  
 070 BROKEN  
 105 LOOSE OR DAMAGED BOLTS  
 106 MISSING BOLTS, SCREWS,  
 111 BURST OR BROKEN  
 116 CUT  
 117 DETERIORATED  
 135 BENDING, STUCK, OR JAMMED  
 170 CORRODED  
 190 CRACKED  
 425 NICKED  
 520 PITTED  
 540 PUNCTURED  
 585 SHEARED  
 605 CRAZED  
 660 STRIPPED  
 731 BATTLE DAMAGE  
 780 BENT, BUCKLED, COLLAPSED  
 846 DELAMINATED  
 878 WEATHER DAMAGE  
 910 CHIPPED  
 917 IMPENDING FAILURE  
 935 SCORED OR SCRATCHED  
 947 TORN

## WHEN DISCOVERED CODES

A - BEFORE FLIGHT - ABORT  
 B - BEFORE FLIGHT - NO ABORT  
 C - IN-FLIGHT - ABORT  
 D - IN-FLIGHT - NO ABORT  
 E - AFTER FLIGHT - AIR CREW  
 F - BETWEEN FLIGHTS - GROUND  
 G - GROUND ALERT - NOT DEGRADED  
 H - BASIC POST FLIGHT  
 J - PREFLIGHT INSP  
 K - POST FLIGHT INSP  
 M - PERIODIC/PHASED INSP  
 N - GROUND ALERT - DEGRADED  
 P - FUNCTIONAL CHECKFLIGHT  
 Q - SPECIAL INSP  
 R - QUALITY CONTROL CHECK  
 S - DEPOT LEVEL MAINTENANCE  
 U - NON-DESTRUCT INSP

## ACTION TAKEN CODES

F - REPAIR  
 G - REPAIR OR REPLACE  
 L - ADJUST  
 P - REMOVE  
 Q - INSTALL  
 R - REMOVE AND REPLACE  
 X - TEST, INSPECT-SERVICE

AIRCRAFT MODEL C-130											
MUC - 11271											
TITLE: FRAME M/G											
DOOR											
TYPE STRUCTURE											
STRUCT. IMPORTANCE											
PART FORM											
PART MATERIAL											
MUC-MMH/EH RANK											
VALUE MMH/1000FH											
MDR RANKING											
MMH RANKING											
IROS COST RANKINGS											
HOW MAL. CODES											
HMC-MDR RANK											
HMC-MMH RANK											
HIGHEST WH DISC. CODE											
HIGHEST ACT. TAKEN CODE											
										OVERALL	STRUCTURE
											AIRFRAME
											LOG GEAR
											FL. CONT.
											OTHER
											PRIMARY
											SECONDARY
											OTHER
											FORGING
											CASTING
											SHEET
											PLATE
											ROD
											BOLTS & FAST
											EXTR:
											H. COMB
											ASSY
											OTHER
											ALUM.
											STEEL
											TITAN
											FIBERGLAS
											MAGNESIUM
											COMBINATION
											TRANSPARENT
										SUMMARY	



# CODE NOMENCLATURE

020 WORN, CHAFED, OR FRAYED  
 070 BROKEN  
 105 LOOSE OR DAMAGED BOLTS  
 106 MISSING BOLTS, SCREWS,  
 111 BURST OR BROKEN  
 116 CUT  
 117 DETERIORATED  
 135 BENDING, STUCK, OR JAMMED  
 170 CORRODED  
 190 CRACKED  
 425 NICKED  
 520 PITTED  
 540 PUNCTURED  
 585 SHEARED  
 605 CRAZED  
 660 STRIPPED  
 731 BATTLE DAMAGE  
 780 BENT, BUCKLED, COLLAPSED  
 846 DELAMINATED  
 878 WEATHER DAMAGE  
 910 CHIPPED  
 917 IMPENDING FAILURE  
 935 SCORED OR SCRATCHED  
 947 TORN

## WHEN DISCOVERED CODES

A - BEFORE FLIGHT - ABORT  
 B - BEFORE FLIGHT - NO ABORT  
 C - IN-FLIGHT - ABORT  
 D - IN-FLIGHT - NO ABORT  
 E - AFTER FLIGHT - AIR CREW  
 F - BETWEEN FLIGHTS - GROUND  
 G - GROUND ALERT - NOT DEGRADED  
 H - BASIC POST FLIGHT  
 J - PREFLIGHT INSP  
 K - POST FLIGHT INSP  
 M - PERIODIC/PHASED INSP  
 N - GROUND ALERT - DEGRADED  
 P - FUNCTIONAL CHECKFLIGHT  
 Q - SPECIAL INSP  
 R - QUALITY CONTROL CHECK  
 S - DEPOT LEVEL MAINTENANCE  
 U - NON-DESTRUCT INSP

## ACTION TAKEN CODES

F - REPAIR  
 G - REPAIR OR REPLACE  
 L - ADJUST  
 P - REMOVE  
 Q - INSTALL  
 R - REMOVE AND REPLACE  
 X - TEST, INSPECT-SERVICE

AIRCRAFT MODEL C-[4]A												
MUC - 12 CAZ												
TITLE: CARGO TIE-												
DOWN FTG (25,000 LB												
TYPE STRUCTURE												
STRUCT. IMPORTANCE												
PART FORM.												
PART MATERIAL												
MUC-MMH/FH RANK	20											
VALUE MMH/1000FH	0.8											
MDR RANKING		63										
MMH RANKING		89										
IRDS COST RANKINGS	11											
HOW MAL. CODES	020											
HMC-MDR RANK	7	4	2	6								
HMC-MMH RANK	8	5	2	6								
HIGHEST WH DISC. CODE	M	F	F	M								
HIGHEST ACT. TAKEN CODE	R	G	G	G								

CODE NOMENCLATURE

020 WORN, CHAFED, OR FRAYED

070 BROKEN

105 LOOSE OR DAMAGED BOLTS

106 MISSING BOLTS, SCREWS,

111 BURST OR BROKEN

116 CUT

117 DETERIORATED

135 BENDING, STUCK, OR JAMMED

170 CORRODED

190 CRACKED

425 NICKED

520 PITTED

540 PUNCTURED

585 SHEARED

605 CRAZED

660 STRIPPED

731 BATTLE DAMAGE

780 BENT, BUCKLED, COLLAPSED

846 DELAMINATED

878 WEATHER DAMAGE

910 CHIPPED

917 IMPENDING FAILURE

935 SCORED OR SCRATCHED

947 TORN

WHEN DISCOVERED CODES

A - BEFORE FLIGHT - ABORT

B - BEFORE FLIGHT - NO ABORT

C - IN-FLIGHT - ABORT

D - IN-FLIGHT - NO ABORT

E - AFTER FLIGHT - AIR CREW

F - BETWEEN FLIGHTS - GROUND

G - GROUND ALERT - NOT DEGRADED

H - BASIC POST FLIGHT

J - PREFLIGHT INSP

K - POST FLIGHT INSP

M - PERIODIC/PHASED INSP

N - GROUND ALERT - DEGRADED

P - FUNCTIONAL CHECKFLIGHT

Q - SPECIAL INSP

R - QUALITY CONTROL CHECK

S - DEPOT LEVEL MAINTENANCE

U - NON-DESTRUCT INSP

ACTION TAKEN CODES

F - REPAIR

G - REPAIR OR REPLACE

L - ADJUST

P - REMOVE

Q - INSTALL

R - REMOVE AND REPLACE

X - TEST, INSPECT-SERVICE

AIRCRAFT MODEL C-141A										WJC - 23PQZ	
TITLE: AFT COMB										DOOR, LEFT	
TYPE STRUCTURE										STRUCT. IMPORTANCE	
PART FORM										PART MATERIAL	
WJC-MMH/FH RANK										VALUE MMH/1000FH	
MDR RANKING										MMH RANKING	
INDS COST RANKINGS										HDC MAL. CODES	
HMC-MDR RANK										HMC-MMH RANK	
HMC-MMH RANK										HIGHEST MM DISC. CODE	
HIGHEST ACT. TAKEN CODE										OVERALL STRUCTURE	
020											
070											
105											
106											
111											
116											
117											
135											
170											
190											
425											
520											
540											
585											
605											
660											
731											
780											
846											
878											
910											
917											
935											
947											
SUMMARY										AIRFRAME	
										LOG GEAR	
										FL. CONT.	
										OTHER	
										PRIMARY	
										SECONDARY	
										OTHER	
										FORGING	
										CASTING	
										SHEET	
										PLATE	
										ROD	
										BOLTS & FAST	
										EXTR:	
										H. COMB	
										ASSY	
										OTHER	
										ALUM.	
										STEEL	
										TITAN	
										FIBERGLAS	
										MAGNESIUM	
										COMBINATION	
										TRANSPARENT	

**ACTION TAKEN CODES**  
**F - REPAIR**  
**G - REPAIR OR REPLACE**  
**L - ADJUST**  
**P - REMOVE**  
**Q - INSTALL**  
**R - REMOVE AND REPLACE**  
**X - TEST, INSPECT-SERVICE**

108

020 WORN, CHAFED, OR FRAYED  
070 BROKEN  
105 LOOSE OR DAMAGED BOLTS  
106 MISSING BOLTS, SCREWS,  
111 BURST OR BROKEN  
116 CUT  
117 DETERIORATED  
135 BENDING, STUCK, OR JAMMED  
170 CORRODED  
190 CRACKED  
425 NICKED  
520 PITTED  
540 PUNCTURED  
585 SHEARED  
605 CRAZED  
660 STRIPPED  
731 BATTLE DAMAGE  
780 BENT, BUCKLED, COLLAPSED  
846 DELAMINATED  
878 WEATHER DAMAGE  
910 CHIPPED  
917 IMPENDING FAILURE  
935 SCORED OR SCRATCHED  
947 TORN

A - BEFORE FLIGHT - ABORT  
B - BEFORE FLIGHT - NO ABORT  
C - IN-FLIGHT - ABORT  
D - IN-FLIGHT - NO ABORT  
E - AFTER FLIGHT - AIR CREW  
F - BETWEEN FLIGHTS - GROUND  
G - GROUND ALERT - NOT DEGRADED  
H - BASIC POST FLIGHT  
J - PREFLIGHT INSP  
K - POST FLIGHT INSP  
M - PERIODIC/PHASED INSP  
N - GROUND ALERT - DEGRADED  
P - FUNCTIONAL CHECKFLIGHT  
Q - SPECIAL INSP  
R - QUALITY CONTROL CHECK  
S - DEPOT LEVEL MAINTENANCE  
U - NON-DESTRUCT INSP

F - REPAIR  
G - REPAIR OR REPLACE  
L - ADJUST  
P - REMOVE  
Q - INSTALL  
R - REMOVE AND REPLACE  
X - TEST, INSPECT-SERVICE

109





**WUC - 118AP**

## FITTING ENGINE

## TYPE STRUCTURE

**STRUCT. IMPORTANCE**

PART FORM

## PART MATERIAL

WUC-MMM/FH RANK

VALUE MMH/1000FH

MDR RANKING

### MMH RANKING

## IRON COST RANKINGS

1

### HOW MAL. CODES

HMC-MDR RANK

**HMC-MH RANK**

HIGHEST IN DIS

HIGHEST ACT. TAKEN CODE	ACT. TAKEN	ACT. TAKEN CODE
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9
10	10	10
11	11	11
12	12	12
13	13	13
14	14	14
15	15	15
16	16	16
17	17	17
18	18	18
19	19	19
20	20	20
21	21	21
22	22	22
23	23	23
24	24	24
25	25	25
26	26	26
27	27	27
28	28	28
29	29	29
30	30	30
31	31	31
32	32	32
33	33	33
34	34	34
35	35	35
36	36	36
37	37	37
38	38	38
39	39	39
40	40	40
41	41	41
42	42	42
43	43	43
44	44	44
45	45	45
46	46	46
47	47	47
48	48	48
49	49	49
50	50	50
51	51	51
52	52	52
53	53	53
54	54	54
55	55	55
56	56	56
57	57	57
58	58	58
59	59	59
60	60	60
61	61	61
62	62	62
63	63	63
64	64	64
65	65	65
66	66	66
67	67	67
68	68	68
69	69	69
70	70	70
71	71	71
72	72	72
73	73	73
74	74	74
75	75	75
76	76	76
77	77	77
78	78	78
79	79	79
80	80	80
81	81	81
82	82	82
83	83	83
84	84	84
85	85	85
86	86	86
87	87	87
88	88	88
89	89	89
90	90	90
91	91	91
92	92	92
93	93	93
94	94	94
95	95	95
96	96	96
97	97	97
98	98	98
99	99	99
100	100	100

CODE NOMENCLATURE

020 WORN, CHAFED, OR FRAYED

070 BROKEN

105 LOOSE OR DAMAGED BOLTS

106 MISSING BOLTS, SCREWS,

111 BURST OR BROKEN

116 CUT

117 DETERIORATED

135 BENDING, STUCK, OR JAMMED

170 CORRODED

190 CRACKED

425 NICKED

520 PITTED

540 PUNCTURED

585 SHEARED

605 CRAZED

660 STRIPPED

731 BATTLE DAMAGE

780 BENT, BUCKLED, COLLAPSED

846 DELAMINATED

878 WEATHER DAMAGE

910 CHIPPED

917 IMPENDING FAILURE

935 SCORED OR SCRATCHED

947 TORN

WHEN DISCOVERED CODES

- A - BEFORE FLIGHT - ABORT
- B - BEFORE FLIGHT - NO ABORT
- C - IN-FLIGHT - ABORT
- D - IN-FLIGHT - NO ABORT
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- G - GROUND ALERT - NOT DEGRADED
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- K - POST FLIGHT INSP
- M - PERIODIC/PHASED INSP
- N - GROUND ALERT - DEGRADED
- P - FUNCTIONAL CHECKFLIGHT
- Q - SPECIAL INSP
- R - QUALITY CONTROL CHECK
- S - DEPOT LEVEL MAINTENANCE
- U - NON-DESTRUCT INSP

**ACTION TAKEN CODES**  
**F - REPAIR**  
**G - REPAIR OR REPLACE**  
**L - ADJUST**  
**P - REMOVE**  
**Q - INSTALL**  
**R - REMOVE AND REPLACE**  
**X - TEST, INSPECT-SERVICE**

[illegible]



020 WORN, CHAFED, OR FRAYED  
070 BROKEN  
105 LOOSE OR DAMAGED BOLTS  
106 MISSING BOLTS, SCREWS,  
111 BURST OR BROKEN  
116 CUT  
117 DETERIORATED  
135 BENDING, STUCK, OR JAMMED  
170 CORRODED  
190 CRACKED  
425 NICKED  
520 PITTED  
540 PUNCTURED  
585 SHEARED  
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947 TORN

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- P - FUNCTIONAL CHECKFLIGHT
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- R - QUALITY CONTROL CHECK
- S - DEPOT LEVEL MAINTENANCE
- U - NON-DESTRUCT INSP

F - REPAIR  
G - REPAIR OR REPLACE  
L - ADJUST  
P - REMOVE  
Q - INSTALL  
R - REMOVE AND REPLACE  
X - TEST, INSPECT-SERVICE

112

020 WORN, CHAFED, OR FRAYED  
070 BROKEN  
105 LOOSE OR DAMAGED BOLTS  
106 MISSING BOLTS, SCREWS,  
111 BURST OR BROKEN  
116 CUT  
117 DETERIORATED  
135 BENDING, STUCK, OR JAMMED  
170 CORRODED  
190 CRACKED  
425 NICKED  
520 PITTED  
540 PUNCTURED  
585 SHEARED  
605 CRAZED  
660 STRIPPED  
731 BATTLE DAMAGE  
780 BENT, BUCKLED, COLLAPSED  
846 DELAMINATED  
878 WEATHER DAMAGE  
910 CHIPPED  
917 IMPENDING FAILURE  
935 SCORED OR SCRATCHED  
947 TORN

A - BEFORE FLIGHT - ABORT  
 B - BEFORE FLIGHT - NO ABORT  
 C - IN-FLIGHT - ABORT  
 D - IN-FLIGHT - NO ABORT  
 E - AFTER FLIGHT - AIR CREW  
 F - BETWEEN FLIGHTS - GROUND  
 G - GROUND ALERT - NOT DEGRADED  
 H - BASIC POST FLIGHT  
 J - PREFLIGHT INSP  
 K - POST FLIGHT INSP  
 M - PERIODIC/PHASED INSP  
 N - GROUND ALERT - DEGRADED  
 P - FUNCTIONAL CHECKFLIGHT  
 Q - SPECIAL INSP  
 R - QUALITY CONTROL CHECK  
 S - DEPOT LEVEL MAINTENANCE  
 U - NON-DESTRUCT INSP

F - REPAIR  
G - REPAIR OR REPLACE  
L - ADJUST  
P - REMOVE  
Q - INSTALL  
R - REMOVE AND REPLACE  
X - TEST, INSPECT-SERVICE

113

947 TORM

U - NON-DESTRUCT INSR

X - TEST, INSPECT-SERVICE

114

WUC - 14318

**STEEL TRAILING EDGE**

### TYPE STRUCTURE

STRUCT. IMPORTANCE

PART FORM

## PART MATERIAL

MUC-MMH/FH RANK

VALUE MMH/1000FH

MDR RANKING

### 1991 RANKING

**1995 COST RANKINGS**

1

**HOW MAL. CO**

HMC-MDR PAN

HMC-MMM RAN

**HIGHEST WH**

**HIGHEST ACT**

100

ED  
S  
,

RAY  
OLT  
EWS

FOR F  
ED B  
SCA

E  
D, C  
MAG  
TS,

TUR  
AFE  
  
DA  
BOL

CL  
C  
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NG

OME  
ORN  
ROK  
DOS  
ISS

DE N  
O W  
O B  
S L  
6 M

CO  
02  
07  
10  
10  
11

100

\_\_\_\_\_

**U - NON-DESTRUCT INSP**

**X - TEST, INSPECT-SERVICE**

115



**ACTION TAKEN CODES**  
**F - REPAIR**  
**G - REPAIR OR REPLACE**  
**L - ADJUST**  
**P - REMOVE**  
**Q - INSTALL**  
**R - REMOVE AND REPLACE**  
**X - TEST, INSPECT-SERVICE**

116



**ACTION TAKEN CODES**  
**F - REPAIR**  
**G - REPAIR OR REPLACE**  
**L - ADJUST**  
**P - REMOVE**  
**Q - INSTALL**  
**R - REMOVE AND REPLACE**  
**X - TEST, INSPECT-SERVICE**

AIRCRAFT MODEL	F-4
MUC -	
TITLE:	NOSE LG
DRAW BRACE FITTING	
TYPE STRUCTURE	
STRUCT. IMPORTANCE	
PART FORM	
PART MATERIAL	
MUC-MMH/FH RANK	
VALUE MMH/1000FH	
NDR RANKING	
MMH RANKING	
IROS COST RANKINGS	
HOW MAL. CODES	
HMC-NDR RANK	
HMC-MMH RANK	
HIGHEST WH DISC. CODE	
HIGHEST ACT. TAKEN CODE	
	OVERALL STRUCTURE
	X AIRFRAME
	LDG GEAR
	FL. CONT.
	OTHER
	X PRIMARY
	SECONDARY
	OTHER
	X FORGING
	CASTING
	SHEET
	PLATE
	ROD
	BOLTS & FAST
	EXTR:
	H. COMB
	ASSY
	OTHER
	X ALUM.
	STEEL
	TITAN
	FIBERGLAS
	MAGNESIUM
	COMBINATION
	TRANSPARENT
(NOT IN AFM66-1 DATA)	
020	
070	
105	
106	
111	
116	
117	
135	
170	
190	
425	
520	
540	
585	
605	
660	
731	
780	
846	
878	
910	
917	
935	
947	
SUMMARY	

020 WORN, CHAFED, OR FRAYED  
070 BROKEN  
105 LOOSE OR DAMAGED BOLTS  
106 MISSING BOLTS, SCREWS,  
111 BURST OR BROKEN  
116 CUT  
117 DETERIORATED  
135 BENDING, STUCK, OR JAMMED  
170 CORRUPTED  
190 CRACKED  
425 NICKED  
520 PITTED  
540 PUNCTURED  
585 SHEARED  
605 CRAZED  
660 STRIPPED  
731 BATTLE DAMAGE  
780 BENT, BUCKLED, COLLAPSED  
846 DELAMINATED  
878 WEATHER DAMAGE  
910 CHIPPED  
917 IMPENDING FAILURE  
935 SCORING OR SCRATCHED  
947 TORN

**WHEN DISCOVERED CODES**

- A - BEFORE FLIGHT - ABORT
- B - BEFORE FLIGHT - NO ABORT
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- G - GROUND ALERT - NOT DEGRADED
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### ACTION TAKEN CODES

F - REPAIR  
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X - TEST, INSPECT-SERVICE

[illegible]

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106 MISSING BOLTS, SCREWS,  
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[illegible]

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G - REPAIR OR REPLACE  
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X - TEST, INSPECT-SERVICE

[illegible]

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070 BROKEN  
105 LOOSE OR DAMAGED BOLTS  
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135 BENDING, STUCK, OR JAMMED  
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947 TORN

**WHEN DISCOVERED CODES**

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- G - GROUND ALERT - NOT OEGRAEO
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G - REPAIR OR REPLACE  
L - ADJUST  
P - REMOVE  
Q - INSTALL  
R - REMOVE AND REPLACE  
X - TEST, INSPECT-SERVICE

AIRCRAFT MODEL	T-37
MUC -	
TITLE: ENGINE	
TAILPIPE CLAMP	
TYPE STRUCTURE	
STRUCT. IMPORTANCE	
PART FORM	
PART MATERIAL	
MUC-MMH/FH RANK	
VALUE MMH/1000FH	
HDR RANKING	
MMH RANKING	
IROS COST RANKINGS	
HOW MAL. CODES	020
HMC-HDR RANK	070
HMC-MMH RANK	105
HIGHEST MH DISC. CODE	106
HIGHEST ACT. TAKEN CODE	111
	116
	117
	135
	170
	190
	425
	520
	540
	585
	605
	660
	731
	780
	846
	878
	910
	917
	935
	947
SUMMARY	



02D WORN, CHAFED, OR FRAYED  
070 BROKEN  
105 LOOSE OR DAMAGED BOLTS  
106 MISSING BOLTS, SCREWS,  
111 BURST OR BROKEN  
116 CUT  
117 DETERIORATED  
135 BENDING, STUCK, OR JAMMED  
170 CORRODED  
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K - POST FLIGHT INSP  
M - PERIODIC/PHASED INSP  
N - GROUND ALERT - OEGRADED  
P - FUNCTIONAL CHECKFLIGHT  
Q - SPECIAL INSP  
R - QUALITY CONTROL CHECK  
S - DEPOT LEVEL MAINTENANCE  
U - NON-OESTRUCT INSP

F - REPAIR  
G - REPAIR OR REPLACE  
L - ADJUST  
P - REMOVE  
Q - INSTALL  
R - REMOVE AND REPLACE  
X - TEST, INSPECT-SERVICE

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